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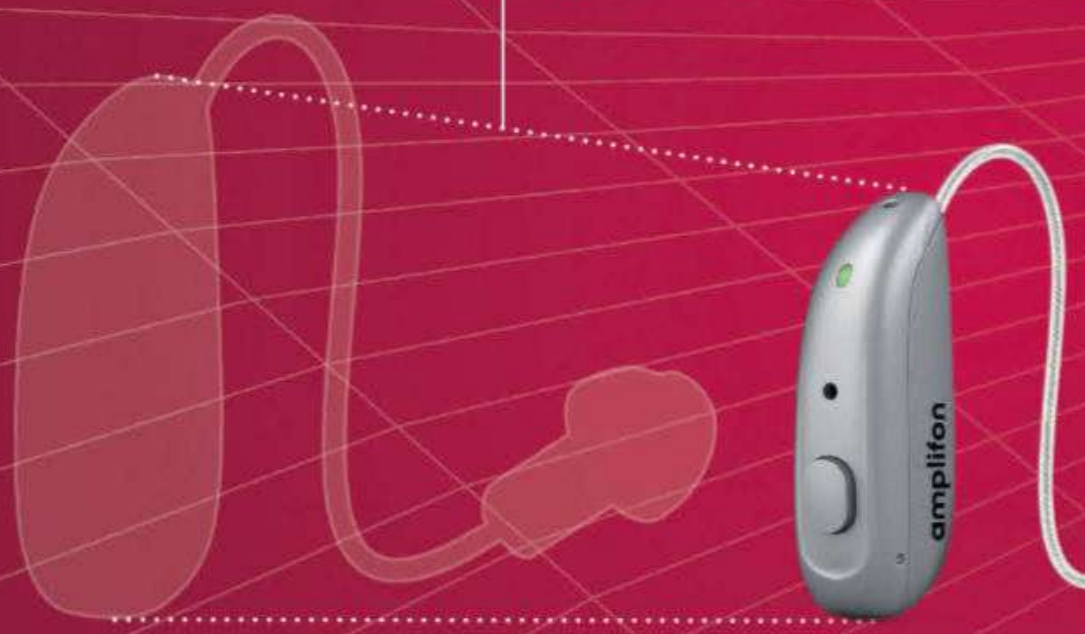

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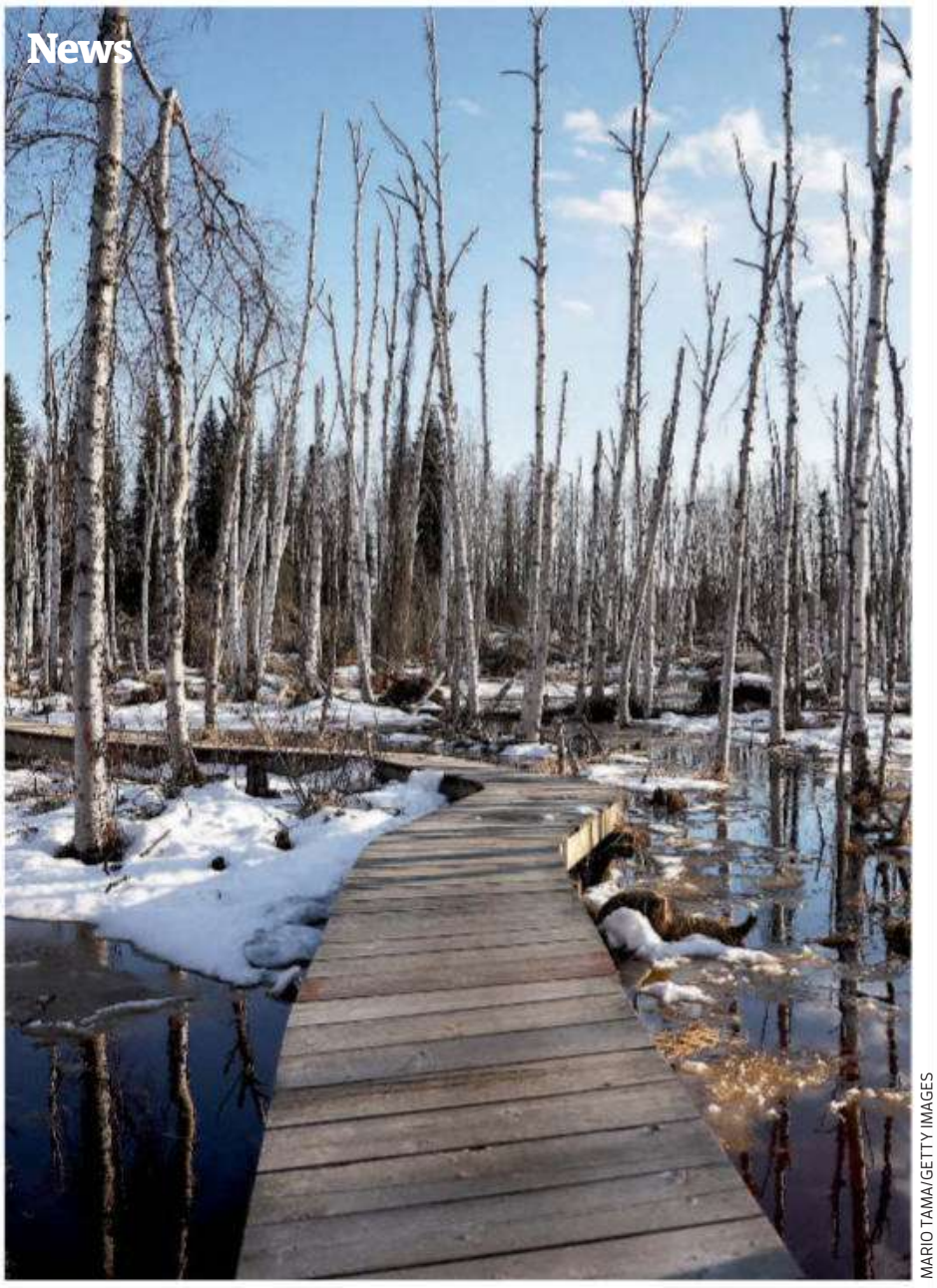

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Elsewhere on New Scientist

Instant Expert

Consciousness: Unlocking the mind

Dive into the mysteries of the human experience with this one-day masterclass exploring the forefront of brain research. Join six leading experts on 22 June at the SVA Theatre in New York to uncover the origins of thoughts and emotions, the meaning of dreams and the connection between material neurons and consciousness.

newscientist.com/events

Tour

Alfred Nobel's Stockholm: Sweden

Join *New Scientist* reporter Alex Wilkins on a walking tour of Stockholm, home of luminaries like Alfred Nobel, Carl Linnaeus and Jöns Jacob Berzelius, whose contributions to botany, astronomy, physics, chemistry and medicine are second to none. Learn about the Nobel prizes, created to reward those who had "conferred the greatest benefit on humankind". This six-day tour starts on 28 September and costs £2544.

newscientist.com/tours

Podcast

Dead Planets Society

In the second season of our absurd and occasionally cataclysmic podcast, *New Scientist*'s Chelsea Whyte and Leah Crane are joined by experts in astronomy, physics and planetary science to tinker with the universe, from shredding Mars with magnets to obliterating a black hole.

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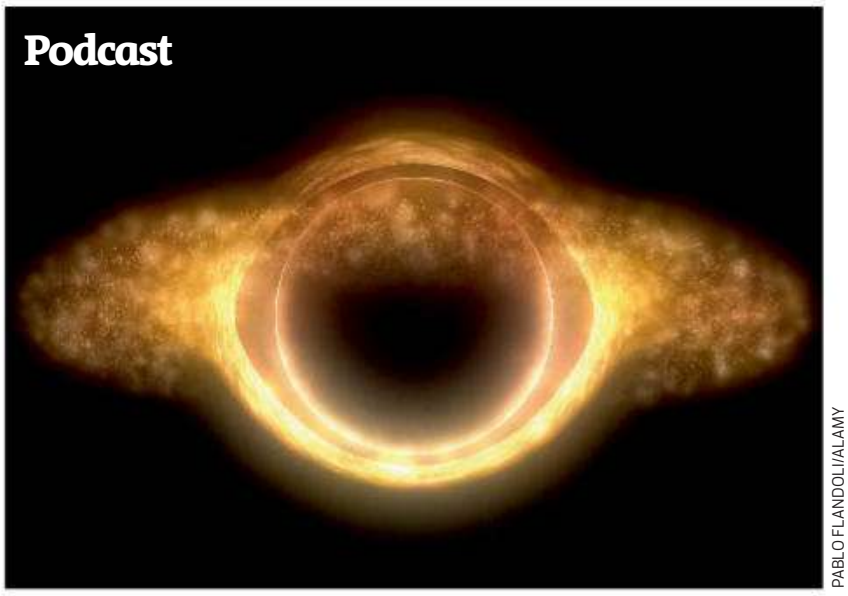


PABLO FLANDOLI/ALAMY

Point of no return Can we obliterate a black hole from the cosmos?

SHUTTERSTOCK/ANDREY SHCHERBUKHIN

Land of laureates Visit Stockholm, home of the Nobel prizes

Video

Eclipse chasers

Last week, two NASA jet planes sped at 740 kilometres per hour alongside the solar eclipse as it travelled across North America. Equipped with visible and infrared cameras that imaged the sun's corona, the research will hopefully determine which structures in the corona emit their own light and which scatter light from the sun's surface.

youtube.com/newscientist

Newsletter

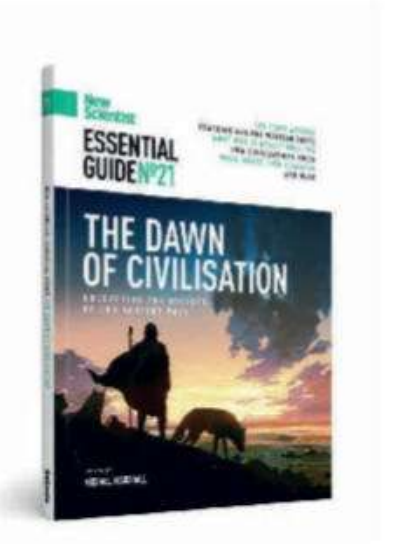
Health Check

Alexandra Thompson rounds up this week's health news, including why we are starting to better understand the causes of long covid and new evidence that many surgical infections may be caused by bacteria already on the skin. Plus, cancer treatments are being developed by targeting mini-tumours in the lab.

newscientist.com/health-check

Video

"We flew the airplanes in tandem so that we doubled the observing time of the eclipse"



Essential guide

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Climate pessimism

Negative thinking is unpopular, but it could drive more realistic efforts to limit harm

PESSIMISM is a dirty word in climate policy circles. There are good reasons for this, not least that optimism can spur positive change, while assuming the worst can paralyse us into inaction. But when it comes to climate modelling, some negative thinking could be a good thing.

The Intergovernmental Panel on Climate Change already hedges its bets with a range of models, or pathways, that assess how we might limit warming to 1.5°C, or see carbon emissions continue unabated, or experience many possibilities in between. These pathways are underpinned by thousands of scientific papers, reams of data and the brains of the world's climate scientists, but, like all models, they are also built on assumptions.

One key assumption in scenarios that keep us below 1.5°C of warming is that, in the near future, we will rapidly perfect technologies that remove carbon dioxide from the atmosphere. This isn't an unreasonable prediction, given human ingenuity and the strong incentives for doing so. But including carbon capture technologies in these models is a bit like declaring you will balance your household budget with a lottery win – if you can't cut your outgoings to an affordable level, you had better hope a big prize is on its way.

> **"The climate change-related challenges facing us in the next decade have just got harder"**

As two stories in this issue demonstrate, this is a risky approach. A detailed analysis of plans for geological storage of carbon dioxide has found that meeting the levels assumed by many 1.5°C pathways is, if not impossible, then at least highly unlikely (see page 8). The odds of that lottery win aren't looking so hot. Meanwhile, we have also received an unexpected carbon bill, in the form of melting Arctic permafrost releasing more greenhouse gas than has previously been accounted for (see page 9).

Such revisions in our understanding of climate change are both entirely expected and to be welcomed, but they show that the challenges facing us in the next decade have just got harder. Instead of squeezing climate models until the numbers just about fit the 1.5°C target, perhaps a more pessimistic outlook would better accelerate efforts to limit the damage. ▮

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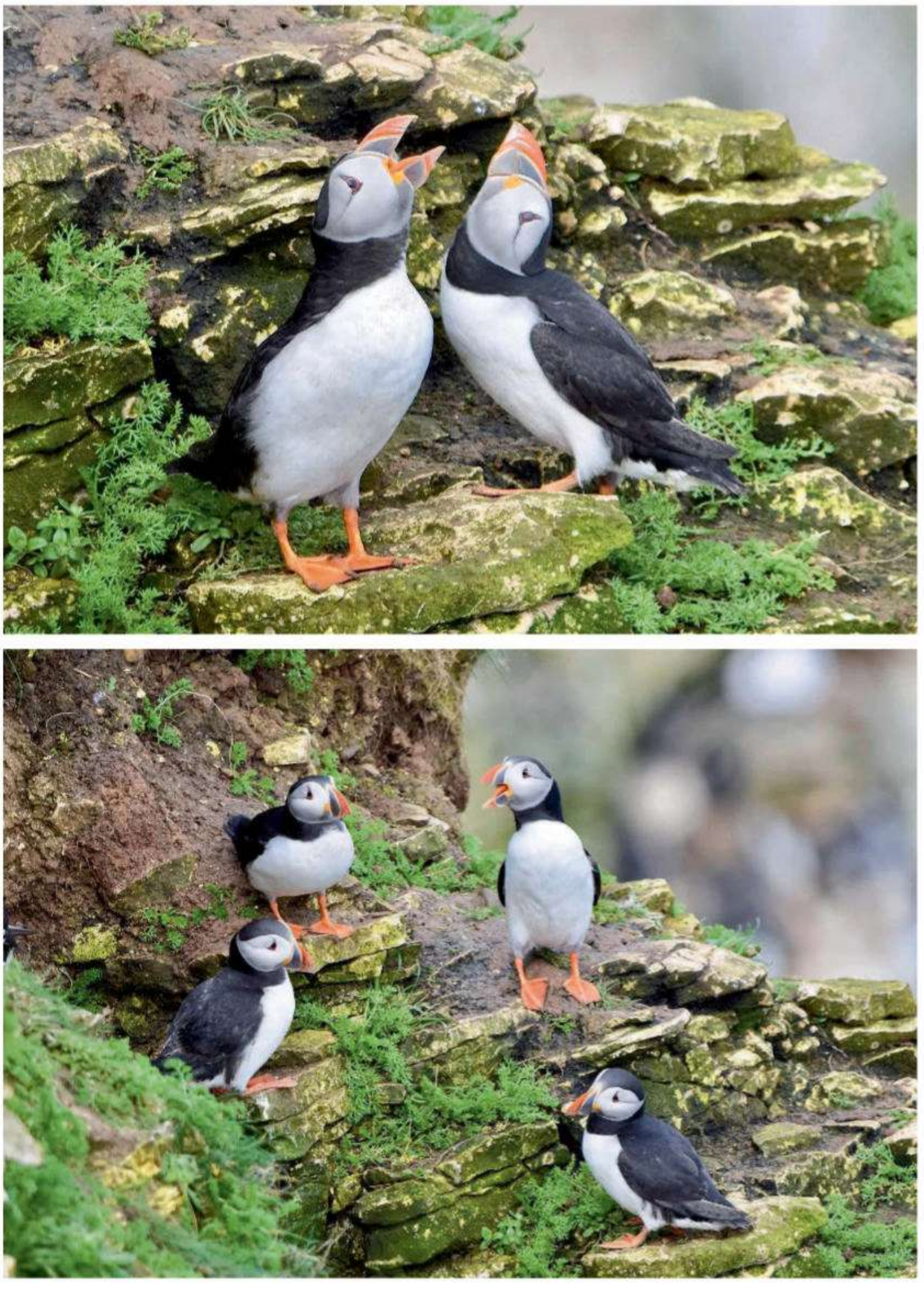


JAMES DAVIES/RSPB

Wildlife

Puffins arrive for breeding season

The multicoloured bills of Atlantic puffins (*Fratercula arctica*) can be seen on UK shores again, returning to breed after overwintering at sea. The ones pictured here are at Bempton Cliffs Nature Reserve in East Yorkshire, the UK's largest mainland seabird colony. About one in four puffins have been lost in the UK since 2000, but there is hope of a reverse after the announcement earlier this year of a ban on fishing in British waters for sand eels, which are an important food source for the birds.

Climate change

Key carbon plan is unworkable

Climate models assume we can slow global warming by storing carbon dioxide underground, but the numbers don't add up, finds **Madeleine Cuff**

PLANS to tackle climate change by sucking carbon dioxide from the air and storing it underground are wildly unrealistic, according to a new analysis, calling into question our ability to meet climate goals.

Humanity has now released so much carbon dioxide into the atmosphere that is impossible for the planet to remain below 1.5°C or 2°C of warming above pre-industrial levels simply by halting emissions. Instead, most climate models that stay below these temperatures assume we will have to actively remove CO_2 from the atmosphere in various ways (see "Carbon clean-up", below right) and find somewhere else to put it.

"We have been extremely ambitious to set a target of limiting global temperature increases to 1.5°C"

These models, known as integrated assessment models (IAMs), play a key role in climate policy-making, setting out potential pathways for global decarbonisation. Their outcomes inform the scientific assessments made by the Intergovernmental Panel on Climate Change (IPCC) on global temperature goals and support governments in drawing up emissions-cutting strategies. In short, it is vital that they are as accurate and realistic as possible.

But IAMs seem to have massively overestimated one carbon storage method, known as geological storage, which involves capturing CO_2 and pumping it underground into places such as depleted oil and gas reservoirs. Currently, around 9 million tonnes of CO_2 are stored in this way each year, but to stay below 1.5°C, most IAMs assume this rate of storage will need to increase 1000-fold to around 9 gigatonnes by mid-century. Some go even further, requiring double or triple this expansion.

Such rapid scaling is unfeasible, says Samuel Krevor at Imperial College London. He and his colleagues used a new approach to assess the likelihood of delivering gigatonne-scale carbon storage by 2050, taking into account geological, economic, technological and geographic constraints on growth (Research Square, doi.org/mrnn).

They conclude that the maximum geological storage possible by 2050 is 16 gigatonnes a year, but such a scenario is unrealistic, relying on huge growth, sustained over decades. It also requires the US to deliver 60 per cent of the total annual storage – 10 gigatonnes per year – by 2050, far beyond the 1 gigatonne it has promised by that date.

"It's just really hard to envision a situation where the US would incentivise that much," says Krevor. A more realistic scenario, which takes into account the US's stated goal, sees the world hit around 6 gigatonnes of annual geological storage by mid-century. "The projections that are above 6 gigatonnes, certainly above 10 gigatonnes… it's difficult to see how that would work," he says.

The team's most conservative scenario assumes a 10 per cent annual growth rate for geological storage from now until 2050, which is still higher than the average annual growth rate of 8.6 per cent seen between 1996 and 2020. Under this scenario, annual storage capacity reaches less than 1 gigatonne per year by 2050, well below what climate models assume will be needed to deliver the 1.5°C temperature goal.

The study, which hasn't yet been peer-reviewed, considers only the regions that have existing carbon-capture-and-storage projects or ones due to be up and running by 2030 – limiting its focus to 10 regions covering North America, the European Union, the UK, Australia and parts of Asia.

Krevor says IAMs are overestimating the delivery of carbon sequestration partly because they don't account for difficulties in scaling the nascent industry, particularly in areas of Asia where current deployment is low. Some of the projections made for carbon storage in China and Indonesia by 2050 assume such massive increases in deployment that it "boggles the mind", he says.

ANDREA GJESTVANG/BLOOMBERG/GETTY

Carbon clean-up

Before we can store carbon, we must capture it. These are the main technologies for doing so.

CARBON CAPTURE: Factories and power stations are equipped with devices that can separate and capture the site's carbon dioxide emissions before they enter the atmosphere. Current technology – which has been operating commercially since 1972 – can remove around 90 per cent of emissions, but it is expensive.

BIOENERGY WITH CARBON CAPTURE: This process involves extracting energy from plant material, such as by burning it in a power station and capturing the emissions given off. In theory, the resulting energy is carbon negative, because, along with the captured emissions, the plants have absorbed carbon while growing. But opponents say the idea is unproven at scale and requires huge amounts of land.

DIRECT AIR CAPTURE: These technologies extract CO_2 directly from the atmosphere, either using sorbent materials or a liquid solvent. They deliver truly negative emissions and can operate in any location untethered from pollution sources. However, current versions are yet to scale up and are extremely expensive and energy intensive.

A project in Blomoyna, Norway, aims to pump CO_2 under the ocean

Models can also skirt over some of the practicalities of using geological storage, such as how quickly reservoirs can be filled. "A reservoir is like a cup. You can pour at a fast rate for a long time. But as you approach the limit, you have to slow down. It's not just about the volume that's there, it's about how quickly you can use it," says Krevor.

"This is something that many of these models need to work on," says Alaa Al Khourdajie at Imperial College London, who wasn't involved in the study.

Even before the team's analysis, the possibility of remaining below 1.5°C of warming was seen as increasingly unlikely, requiring the heavy industry and energy and transport sectors to be decarbonised in just a few decades. Without large-scale carbon storage, that task is even tougher, either demanding faster and more extensive emissions cuts or the use of riskier mitigation strategies, such as geoengineering. Such revisions are likely to be included in the next round of IPCC assessments, due in 2029.

Climate modelers will always work to find a solution that fits a temperature target, says Roberto Schaeffer at the Federal University of Rio de Janeiro, Brazil. However, as the remaining carbon budget for the 1.5°C temperature threshold shrinks, the solutions will become ever more drastic.

"The real issue here is that we have been extremely ambitious to set a target of limiting the temperature [rise] to 1.5°C," says Schaeffer "It's not that the solutions of the model are unrealistic. Eventually what is unrealistic is the target itself." ▮

Carbon emissions

Arctic permafrost is now a net emitter of major greenhouse gases

Alec Luhn

AREAS of permanently frozen ground in northern regions are now emitting more carbon into the atmosphere than they absorb, causing the planet to heat even further, according to the first Arctic-wide estimate of all three major greenhouse gases.

Frozen ground, or permafrost, which underlies 15 per cent of the northern hemisphere and contains twice as much carbon as the atmosphere, has shrunk in area by an estimated 7 per cent in 50 years as it thaws. Recent research suggests the thaw will slow but not stop if we can limit global warming to 1.5°C above pre-industrial levels.

Yet scientists haven't been sure whether the permafrost region has become a net emitter of greenhouse gases. Even as the thaw releases more carbon compounds from the once-frozen biological matter in the ground, increased summertime plant growth is absorbing more carbon dioxide from the atmosphere.

A 2019 study found that the Arctic was emitting more CO_2 than it was absorbing, but research in 2021 and 2023 suggested that it was still a net sink for the gas.

Now, Justine Ramage at the Nordregio research institute in Stockholm, Sweden, and her colleagues have found that the permafrost region has tipped from sink to source, emitting 144 million tonnes of carbon per year between 2000 and 2020. That is largely because methane emissions were included in the measurement in addition to CO_2. Permafrost also emitted 3 million tonnes of nitrogen per year, partly in the form of nitrous oxide, an even more powerful greenhouse gas.

"You put some frozen food in a freezer, it's OK. As soon as you take it out, it starts rotting very fast," says Ramage. "The [microbial] activity starts increasing, and when it's not positive for climate, it will have a strong impact."

While previous research often relied on satellite data or machine learning, Ramage and her colleagues compiled ground-level emission observations from 200 sites across Scandinavia, Russia, Alaska and Canada and extrapolated them to areas with similar plants and moisture.

Melting permafrost exposed an eroding cliff in the Arctic tundra in Alaska

PEPOP IMAGES/ALAMY

Vegetated areas were mostly carbon sinks, but these were offset by emissions from rapidly expanding lakes, as well as wildfires, which weren't taken into account by earlier studies (*Global Biogeochemical Cycles*, doi.org/mrm9).

The estimates have large uncertainty ranges because greenhouse gas monitoring, while improving, is still patchy in remote Arctic areas. "Abrupt thaw", which includes collapses and landslides, is especially difficult to quantify, says Eugénie Euskirchen at the University of Alaska Fairbanks. "It's really hard to constrain and really hard to make measurements because you have to be right on top of it."

144
Million tonnes of carbon emitted by Arctic permafrost per year

Ramage's study found that abrupt thaw released 31 million tonnes of CO_2 and 31 million tonnes of methane per year between 2000 and 2020, but it didn't include these figures in the total carbon estimate for fear of double counting. If anything, the total probably underestimates abrupt thaw, as well as wintertime emissions, says Euskirchen.

Susan Natali at the Woodwell Climate Research Center in Massachusetts, who led the 2019 permafrost emissions study and was a co-author of the "more complete story" provided by Ramage's paper, says permafrost's shift from sink to source will make climate change even worse than expected.

"This is a new source of greenhouse gases to the atmosphere that are not fully accounted for in global climate models," she says. ▮

Health

Progression of Parkinson's disease slowed by antibody drug

David Cox

AMELIE-BENOIST/BSIP SA/ALAMY

With few medications, Parkinson's treatment often involves physiotherapy

A DRUG that targets a build-up of proteins linked to Parkinson's disease could slow the progression of symptoms like tremors in people with advanced forms of the condition who lose motor control.

The accumulation of a misfolded protein called alpha-synuclein in the brain has long been considered the underlying cause of Parkinson's. This leads to the loss of neurons that produce the neurotransmitter dopamine, which is involved in our control of movements.

Some treatments aim to ease symptoms by boosting dopamine levels in the brain, but their long-term effects are limited. So far, there are no approved disease-modifying therapies that halt or slow the progression of Parkinson's.

To see if a drug called prasinezumab could make a difference, Gennaro Pagano at Swiss pharmaceutical company Roche and his colleagues recruited 316 people thought to have early-stage Parkinson's disease. Of these individuals, 105 received intravenous infusions of a placebo, while 211 had infusions of prasinezumab at either a low or high dose, administered every four weeks over one year.

The drug is an antibody designed to bind to aggregations of misfolded alpha-synuclein in dopamine-producing neurons. "It is hypothesised that prasinezumab may reduce neuronal toxicity, prevent cell-to-cell transfer of pathological alpha-synuclein aggregates and slow disease progression," says Pagano.

The trial results initially suggested that the antibody had no meaningful impact, but an additional analysis showed it was more effective among those with more severe Parkinson's.

These individuals had rapid eye movement sleep behaviour disorder, where people act out intense and often violent dreams, which is common in Parkinson's; or were taking drugs called MAO-B inhibitors to manage Parkinson's symptoms; or had been rated by their specialist as being at stage two out of five on a symptom scale, with a higher number indicating greater severity.

Compared with taking a placebo, prasinezumab reduced the rate at which participants' motor symptoms worsened over the year. For example, on a rating scale for motor symptoms, those on MAO-B inhibitors who received the placebo scored 6.82 at the end of the year, while those taking the inhibitors and prasinezumab scored 4.15. No serious adverse events occurred in the trial (*Nature Medicine*, doi.org/mrn4).

"The results imply that in a faster-progressing population, where the degree of worsening over time is greater, there is an increased likelihood of a potential treatment effect," says Pagano. This could be because people with rapidly progressing Parkinson's have higher amounts of misfolded alpha-synuclein in their brains, so may benefit more from a drug that potentially clears the protein.

However, the researchers didn't assess what was happening in participants' brains because they lacked a biomarker to monitor if levels of misfolded alpha-synuclein changed.

"Prasinezumab reduced the rate at which the participants' motor symptoms worsened"

Vinata Vedam-Mai at the University of Florida Health says that without knowing if alpha-synuclein is being cleared, the study can't conclusively show that prasinezumab is disease-modifying. She would also like to see longer-term data to better gauge safety and efficacy. ▮

Technology

Cyborg cockroach swarm is controlled by computers

Matthew Sparkes

A SWARM of remote-controlled cyborg cockroaches can navigate to a target location while avoiding obstacles and each other.

Hirotaka Sato at Nanyang Technological University in Singapore and his colleagues have previously shown that a Madagascar hissing cockroach (*Gromphadorhina portentosa*) can be controlled by a computer and steered like a robot.

The insects wear "backpacks" consisting of a battery, a tiny computer and an antenna to communicate with a central computer. The researchers issued commands through electrodes implanted in sensory organs known as cerci on each side of the animals. When the electrodes applied current to the left or right cercus, the cockroach rotated in that direction.

Now, the researchers have shown that a swarm of 20 such cyborgs can travel as one across a sandy, hilly test area 3.5 square metres in size (arXiv, doi.org/mrnw).

To coordinate the swarm, software on the central computer assigns some cockroaches as leaders that nearby insects follow to the target. The computer dictates the direction in which the cyborgs move, but the movement of their limbs – which is hard to replicate mechanically and electronically – is handled by the cockroaches.

In the test, when a cockroach accidentally rolled onto its back, nearby insects would work together to right it. This is an intrinsic behaviour, not one directed by the computer, says Sato.

The insects could be used to survey areas, taking environmental readings via onboard sensors or to search for humans trapped in rubble, says Sato. The swarm could be carried by a larger robot and then released, sending data to a central computer, he says. It could return to the robot for food and water and to recharge the control backpacks. ▮

Zoology

Are pandas bad at sex because they have the wrong gut microbes?

Sofia Quaglia

GIANT pandas aren't mating enough to grow their populations, and their gut microbes might be to blame.

Habitat destruction and climate change already make it hard for giant pandas to survive. They also face an additional challenge: they struggle to reproduce, especially

"We're not sure yet whether this is the only real reason for their poor sexual performance"

in captivity. Pandas are solitary creatures, and females have just one fertile window of about 40 hours each year. Meanwhile, captive males aren't very promiscuous, and they don't know how to mount females properly.

We have long been trying to understand why captive pandas are so bad at sex: studies show the psychological stress of being stuck in confined spaces probably plays a part, as does the lack of mating competition.

PETE OXFORD/STEVE BLOOM IMAGES/ALAMY

Two pandas munching on bamboo in Sichuan province, China

But Dingzhen Liu at Beijing Normal University and colleagues had a hunch that diet might be responsible too. When they analysed 72 faecal samples from 20 different male giant pandas – some good at mating, others not so much – they discovered one stark difference: the sexually competent group had a significantly higher abundance of *Clostridium* bacteria (*Ecology and Evolution*, doi.org/mrm8).

Since gut microbes influence everything from immunity to behaviour, this lack of *Clostridium* could be inhibiting panda libido.

"We've found the relationship, but we're not sure yet whether this is the only real reason for their poor sexual performance," says Liu. The bigger picture is probably more complex, says Liu, with different plausible factors weighing in.

"This has very important implications for conservation," says Megan Owen at San Diego Zoo Wildlife Alliance in California.

It could help conservationists tweak how pandas are fed in captivity. Previous research has shown that, to help boost *Clostridium* in the gut, pandas can eat more bamboo shoots as well as more flavonoid compounds.

To achieve this, Liu suggests rotating the types of bamboo that pandas are fed in captivity to mimic the seasonal changes they would experience in the wild. ▮

Astrophysics

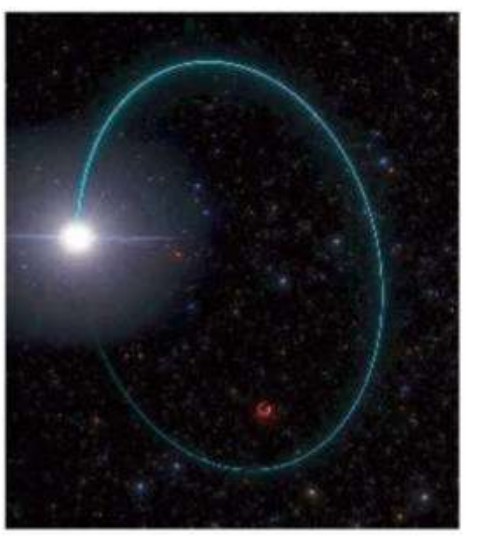
Surprisingly huge black hole found in our galaxy

ASTRONOMERS have found the largest stellar black hole ever seen, dubbed Gaia-BH3. It has a mass 33 times that of the sun, dwarfed only by supermassive black holes and those that formed through mergers of other black holes.

At about 2000 light years away, Gaia-BH3 is also the second-nearest black hole to Earth ever discovered. George Seabroke at University College London and his colleagues found this stellar black hole using the Gaia space telescope. A stellar black hole forms from a star that has reached the end of its life.

No light can escape a black hole, so most of them are found by spotting the glow of the hot material orbiting them and falling in. However, Gaia-BH3 is dormant, not devouring any material. Instead, the researchers found it by noticing the strange motion of a star that seemed to be orbiting a patch of empty space (*Astronomy & Astrophysics*, doi.org/mrq6).

This star itself is unusual, too – it is made almost entirely of hydrogen and helium. Most stars contain at least some heavier elements, which formed in the hearts of massive stars and were distributed throughout space by supernovae. But the first generations of stars would have had very low amounts of heavy elements. The composition of Gaia-BH3's partner star suggests that the enormous star that collapsed to form Gaia-BH3 was also one of these primitive objects, which may have evolved differently from the way massive stars do today.



ESO/L. CALÇADA

Artist's impression of the orbits of black hole Gaia-BH3 (the red circle) and its companion star

This would explain how the black hole got so huge. Its size would be difficult to account for if it had evolved more like regular stars do.

Finding such a massive black hole wasn't a complete surprise. Experiments that hunt for gravitational waves – ripples in space-time caused by the motions of heavy objects – have found signs of them in other galaxies. "From these gravitational wave measurements, we should be expecting to see such black holes in our own galaxy, but we hadn't until now," says Seabroke. ▮

Leah Crane

Physics

A crystal made only of electrons

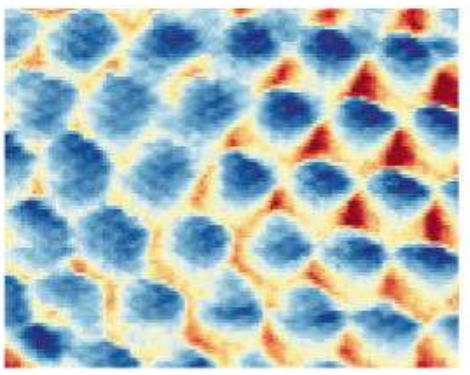
Exotic material has now been seen under a microscope in unprecedented detail

Karmela Padavic-Callaghan

SCIENTISTS have managed to directly image a crystal made only of electrons, known as a Wigner crystal, and their images are the clearest ones yet.

"There have been many, literally hundreds, of papers written on finding evidence for the Wigner crystal," says Ali Yazdani at Princeton University. "And we never thought that we would succeed in [directly] imaging it. It was a bit of an accident."

At room temperature, electrons can flow together in electric currents because their kinetic energy – which comes from their motion – overcomes the force that makes particles with the same electric charge repel each other. At very low temperatures, however, repulsive electric forces win out, and the electrons end up arranging themselves into a uniform grid, or a crystal. Physicist Eugene Wigner predicted this phenomenon in 1934, but researchers only recently started to understand how to create it in the lab.



YAZDANI LAB, PRINCETON UNIVERSITY

This is the first direct look at a bizarre crystal that comprises just electrons

Yazdani and his colleagues made their Wigner crystal from electrons inside two thin sheets of graphene, each only one atom thick. They cooled the graphene to only a few hundredths of a degree above absolute zero and immersed it in a strong magnetic field.

Yazdani says that it was crucial that their graphene had very few imperfections where electrons could get stuck. Otherwise, the particles could form a crystal-like state involving the structure of those imperfections, rather than because of the interactions with each other, as Wigner predicted.

In most past experiments, researchers would look for evidence of a Wigner crystal by creating conditions that would allow them to infer that electrons were locked into a grid, rather than actually being able to see the structure. However, Yazdani's team directly imaged its crystal with a microscope.

The instrument relied on a quantum effect called tunnelling. A sharp metallic tip scanned across the graphene's surface and, when it passed over an electron, the particle would tunnel through the gap between the surface and the tip, creating a small electric current. Because of these currents, the researchers knew where the electrons were positioned in the graphene, letting them create the most precise images of a Wigner crystal yet (*Nature*, doi.org/gtqmvg).

"We never thought that we would succeed in directly imaging a Wigner crystal. It was a bit of an accident"

Yazdani and his colleagues saw electrons sitting at vertices of repeating triangles, just as Wigner predicted. When they applied an electric voltage to the material, altering the temperature and the strength of the magnetic field, the crystal "melted" into an exotic, incompressible electron fluid, as well as a fluid where electrons formed stripes. ▮

Marine biology

Deadly upwellings of cold water pose threat to marine life

BURSTS of frigid water rising from the deep sea to the surface can be deadly for marine animals and such events are increasing in frequency due to climate change.

In March 2021, hundreds of fish and shellfish, as well as squid, octopuses, manta rays and bull sharks, washed up dead on the coast of South Africa.

The animals were fleeing high water temperatures from a heatwave gripping South Africa's coastal zone. But in their escape, they were caught in a sudden cold water upwelling from the region's Agulhas current, prompting ocean temperatures to plummet.

MARTIN PROCHAZKACZ/SHUTTERSTOCK

Migrating bull sharks can be vulnerable to sudden shifts in water temperature

"The temperature can suddenly drop by about 10°C [18°F] in 24 hours," says Zoe Jacobs at the University of Southampton, UK. "It's a very, very intense, short-lived event."

Nicolas Lubitz at James Cook University, Australia, and his colleagues studied 41 years of sea surface temperature data and 33 years of wind records to assess cold water upwelling in the two regions affected by the Agulhas current and the Australian current, which snakes down Australia's east coast.

They conclude that stronger ocean currents and changes in wind patterns, which are occurring with climate change, are driving an increase in the frequency and intensity of cold water upwelling in both regions (*Nature Climate Change*, doi.org/mrn2).

Most marine life living near these currents is adapted to sudden temperature fluctuations, but the study warns that migratory species such as bull sharks, which pass through these waters and are unprepared for sharp shifts in temperature, are at risk. Bull sharks struggle to survive when water temperatures drop below 19°C (66°F) for a sustained period. ▮

Madeleine Cuff

Technology

Bottle purifies water using your body's static electricity

Jeremy Hsu

A BOTTLE can disinfect drinking water by channelling static electricity built up from just 10 minutes of walking.

"Our water disinfection approach holds particular significance for populations in underdeveloped regions, isolated areas, disaster zones and conflict areas lacking adequate sanitation infrastructure," says Sang-Woo Kim at Yonsei University in South Korea.

Kim and his colleagues took a reusable 500-millilitre water bottle and installed a polymer electrode inside that incorporates nanorods made from the conducting polymer polypyrrole. Those nanorods concentrate the electrostatic charges that accumulate on the body as we walk to create electric fields strong enough to kill or otherwise inactivate bacteria and viruses.

A small piece of aluminium foil attached to the outside of the bottle serves as a gripping point, while also collecting static electricity from the person's hand, which then flows along a copper wire to reach the electrode inside the bottle.

Tests showed that the method can completely disinfect river water containing both bacteria and viruses within 10 minutes – and sometimes faster if the person holding the bottle picks up the walking pace (*Nature Water*, doi.org/mrd3).

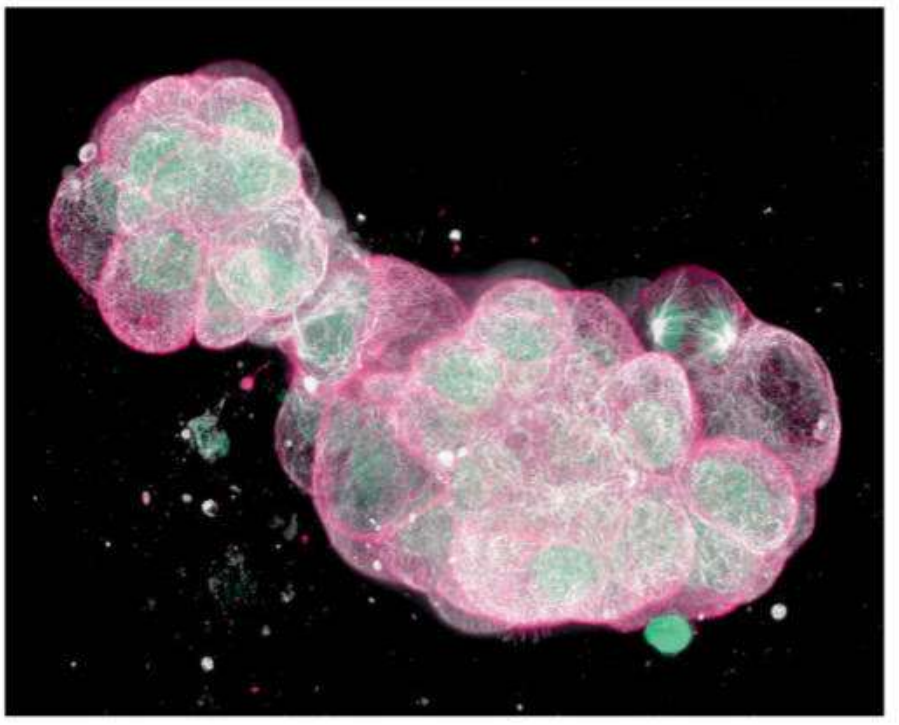
The choice of footwear affects the amount of electrostatic charge harvested. Shoes made from polycarbonate, rubber and polyvinyl chloride enabled higher electrical output than shoes made from leather, says team member Zheng-Yang Huo at Renmin University of China. Very humid conditions can also reduce the effectiveness.

Still, with an estimated cost of under $2 per bottle, the method could be useful in places where clean water and stable electricity supplies are hard to find. ▮

Medicine

Lab-grown mini-tumours could revolutionise cancer therapy

Clare Wilson



DR TORSTEN WITTMANN/SCIENCE PHOTO LIBRARY

Human colon cancer cells forming into a clump in the lab

THE next innovation in cancer treatment could be to test all possible drugs on mini versions of a person's tumour, grown in the lab, to see which works the best. The technique, sometimes called drug sensitivity testing, has now been used in a trial in children with advanced cancer and may have helped them live for longer than they would have with the standard approach.

It could eventually become routinely used for everyone with cancer, says Diana Azzam at Florida International University in Miami. "I would say it will help guide treatments in any [cancer]."

The cells used for growing the mini-cancers are obtained when someone has biopsies of their tumour or when they have surgery to remove it.

The approach means more than 100 different cancer drugs or combinations of drugs can be tested on thousands of clumps of cells grown in small dishes. The treatment that proves most effective at stopping the cells from multiplying can then be used as a therapy.

Currently, doctors select the drug that is usually employed against that cancer type or use their judgement to choose between a few options. If the first treatment fails to shrink the tumour, a different drug is tried, but this trial-and-error process can take months and can have harsh side effects.

"Detrimental side effects occur that lower a patient's overall health and make it much harder to continue treatment," says Azzam. "The only way we can provide the right drug for the patient at the right time is to actually test drugs on tumour cells and find out which ones work and which don't."

"The only way we can provide the right drug at the right time is to test drugs on tumour cells"

The drug sensitivity testing approach has been in development for several years, but there had been only one previous trial, in adults with late-stage blood cell cancers, such as leukaemia. This work suggested that the technique lets people live for longer.

Now, Azzam and her team have found signs that the approach helps children with solid tumours too. They studied 21 children with either tumours or blood cancers that had returned after multiple previous treatments, so had a poor prognosis. The drug sensitivity testing led to a recommended treatment for 19 of the participants. Only six had the advised treatment, as some doctors overrode the advice and some children deteriorated so fast that they had to withdraw from the study.

Of the six who had the advised treatment, five had a remission of their cancer that lasted 8.5 times longer, on average, than after their previous cancer treatment (*Nature Medicine*, doi.org/mrd2).

This suggests drug sensitivity testing leads to a more potent treatment, because usually a cancer remission period lasts for a shorter time after each new cancer treatment, says Maddy Parsons at King's College London. "[Considering] it's a relatively unsophisticated cell culture driven by the need for speed, it's incredible how well it works."

The next step is to try the approach in a randomised trial, says Azzam.

"There are always patients who will not respond to the first line of therapy," says Parsons. "While they're not responding, their cancer is getting worse." The goal is to predict right from the start who will respond best to what drug, she says. ▮

Zoology

‘Peaceful’ bonobos may be more aggressive than chimps

James Woodford

HAVE we misjudged our two closest relatives? Chimpanzees are known for lethal violence while bonobos are widely seen as paragons of coexistence, free love and female empowerment, but a new study suggests the reality is more complicated.

Maud Mouginot at Boston University in Massachusetts and her colleagues studied 12 males from bonobo groups at the Kokolopori Bonobo Reserve in the Democratic Republic of the Congo and 14 males from chimpanzee groups at Gombe National Park in Tanzania.

The researchers tracked each primate from when they woke up each morning to when they returned to their nests at night, recording every aggressive incident. They logged more than 2000 hours following the bonobos and in excess of 7300 hours tracking chimpanzees.

Aggressive behaviours included contact aggression – such as hitting, pulling, biting or kicking – and non-contact aggression, such as charging and chasing.

The team found that bonobo males had 2.8 times as many aggressive interactions as chimp males in total, and three times as many incidents of contact aggression.

9300+

Number of hours spent recording primate behaviour

Chimp aggression was more likely to involve coalitions of males and to be directed towards females, whereas male bonobo aggression towards females was rare (*Current Biology*, doi.org/mrfj). “I was not expecting to find such rates of aggression among [bonobo] males,” says Mouginot.

Bonobo males that acted more aggressively towards other males were more likely to mate with females while they were fertile.

According to Mouginot, one explanation for behavioural disparities could be the differences in bonobo and chimpanzee coalitions. “In bonobos, females form coalitions but rarely males,” she says. “In chimpanzees, males form coalitions against within-group males or to defend a territory. Therefore, if one [chimpanzee] male acts aggressively against another one, he might face a coalitionary retaliation.”

The study also found that male-female interactions are very different between the two species. In bonobos, males avoid acting aggressively towards females and form close associations with them.

“Researchers often refer to chimpanzees, or sometimes bonobos, as the ‘best model’ for our last common ancestor,” says Mouginot. “I think none of those species are a good model – they all went through their own evolutionary path. What is interesting is to look at how some strategies evolve in some species and not others.”

Joan Silk at Arizona State University says this data suggests that bonobo males are at least as aggressive as chimpanzee males, which isn’t what we would expect of “peaceful” apes.

However, Gisela Kaplan at the University of New England in Armidale, Australia, says the paper misuses the word “aggression”. Chimpanzee groups are ruled by one dominant male, whereas bonobos are ruled by females. Competitions for dominance and mating rights in bonobos shouldn’t be confused with aggression, she says. “There’s more pointless violence in chimpanzees and humans than in other species like bonobos.” ▮

Bonobos often act aggressively, despite their peaceful reputation

SERGEY URYADNIKOV/ALAMY

Health

Post-op infection is often due to skin-dwelling microbes

Chen Ly

SURGICAL infections could mainly be caused by bacteria that already live on your skin, rather than via external contamination, according to a study of just over 200 people who underwent spinal procedures.

Hospitals have strict hygiene standards – including sterilising medical clothing and equipment – to prevent an infection, but a US study in 2014 found 3 per cent of people get one after an operation.

To see if such cases could stem from an individual’s skin microbiome rather than hospital conditions, Dustin Long at the University of Washington in Seattle and his colleagues collected skin swabs from 204 people who underwent spinal surgery.

Fourteen of the participants went on to get wound infections. After analysing the microbes responsible, the team found that 12 cases involved bacteria already resident on individuals’ skin before surgery (*Science Translational Medicine*, doi.org/mrmp).

“Virtually all of the SSIs [surgical site infections] we encountered originated from the patient’s own microbiome, rather than pathogens that were introduced from the hospital,” says team member Stephen Salipante, also at the University of Washington.

The researchers expect similar results for any procedure that involves cutting the skin, says Long.

They also found that 59 per cent of the organisms responsible were resistant to pre-surgery antibiotics given to all of the patients in an effort to prevent such infections. “By characterising the antibiotic resistance traits in the microbiome before surgery, antibiotic therapy could be tailored to each individual patient,” says Salipante.

Despite the findings, a clean hospital environment and sterile surgical instruments are still essential, says Long. ▮

Physics

The enigma that was Peter Higgs

The physicist revolutionised our understanding of the universe by theorising the Higgs boson, yet tried to avoid the call from the Nobel prize committee, says **Karmela Padavic-Callaghan**

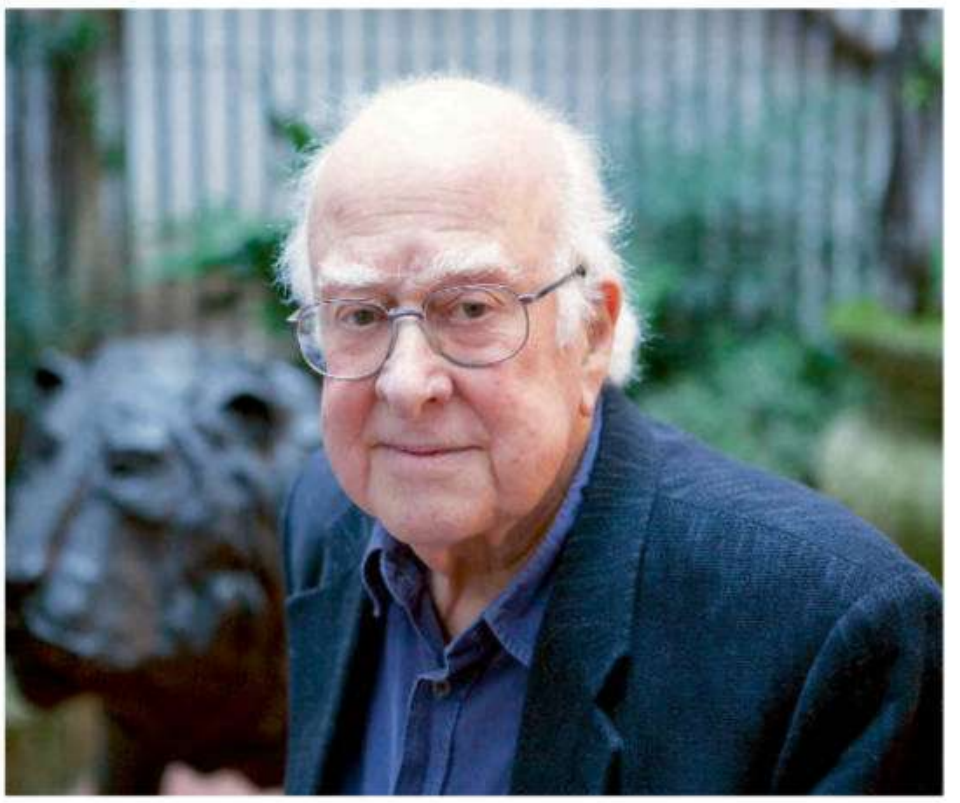
PETER HIGGS lived a singular life. He developed a theory that stood a chance of radically advancing our understanding of the universe, and lived to see generations of experimentalists chase after and eventually corroborate his work. He died in his home, aged 94.

"Without Higgs's work, we wouldn't understand why there are atoms. Some pretty basic features of our world would not be understandable," says John Ellis at King's College London.

Higgs started that work at the University of Edinburgh, UK, in the 1960s. He was thinking about a branch of physics called quantum field theory, and in July 1964, he wrote a short paper on the topic. *Physics Letters* accepted the study but rejected Higgs's more detailed follow-up work just a week later. *Physical Review Letters* eventually published a revised version, but his ideas remained overlooked for years. These papers contained a key ingredient lacking from the theory of all particles in the universe: why they have mass.

Almost all known particles need some mass in order to bind to each other and form the structures, like atoms, that comprise our physical world. But physicists view all particles as excitations of invisible fields that permeate everything – electrons, for example, are excitations of the electromagnetic field – and theories at the time couldn't explain where these masses come from.

Higgs theorised that particles would acquire mass by interacting with a new type of field. That field had a special excitation of its own – a particle called the Higgs boson. The Higgs field solved a huge puzzle in theoretical particle physics, and the Higgs boson was a tantalising target that experimentalists could hunt for to tie theory to reality.



LEONARDO CENDAMO/GETTY IMAGES

Peter Higgs, pictured in Italy in 1996, died on 8 April, aged 94

"If you remove everything from the vacuum, all matter or quantum fluctuations, all electromagnetic stuff, all gravity, you will be left with the Higgs field," says Frank Close at the University of Oxford. "And we need that just like a goldfish needs water. It stabilises empty space."

Working independently from Higgs, physicists François Englert and Robert Brout reached the same conclusion, also in 1964.

However, according to Close, who wrote a biography of Higgs in 2022, Higgs didn't necessarily set out to write a groundbreaking paper. He simply followed a line of often solitary scholarship, which led him to worry about what seemed to be a technical issue that plagued quantum field theory. Other physicists had previously resolved a similar issue in systems, such as perfect conductors of electricity. Higgs figured out how to generalise their mathematics to all of particle physics.

But quantum field theory was unfashionable at the time, and when he lectured about his work at institutions like Harvard University in 1965, Higgs was largely met with scepticism, says Ellis. In 1976, Ellis and two of his colleagues at the CERN particle physics laboratory near Geneva, Switzerland, wrote a paper showing how the Higgs boson could show up in some experiments at the facility.

"Without Higgs's work, some pretty basic features of our world wouldn't be understandable"

"No one really seemed to care, but to us, [the Higgs boson] was extremely important," says Dimitri Nanopoulos at Texas A&M University, who co-authored the paper.

By 1984, views had shifted and physicists were eager to hunt for the Higgs boson. CERN built a new particle collider – the Large Hadron Collider (LHC) – to a great extent to help with the search.

By colliding protons at high speeds and analysing the wreckage, researchers at the LHC found the Higgs boson in 2012. Higgs and Englert shared a Nobel prize in physics the next year.

Finding the boson was the end of one chapter, but not the book, says Nanopoulos. Since 2012, the LHC has been upgraded to produce even more energetic collisions, and researchers have set out to answer lingering questions about not only particles, including the Higgs boson, but also dark energy and dark matter, the unexplained phenomena that make up most of the universe.

After his retirement, Higgs kept working. He was particularly interested in supersymmetry, a theory that posits the existence of heavy counterparts for every type of particle. Many physicists hope the LHC will discover dozens of new particles to back up the idea.

In addition to the Nobel prize, Higgs received many other accolades, including the Paul Dirac Medal and the Wolf Prize in Physics. Yet he was embarrassed by the attention his work garnered, particularly disliking the Higgs boson's sensational nickname, the "God particle". The story of how he even tried to evade the call from the Royal Swedish Academy of Sciences informing him of his Nobel win – by leaving his home without a phone – is well-known lore among physicists.

Close titled his biography of Higgs *Elusive*, which he says described both the man and the boson.

Higgs died at home in Edinburgh on 8 April after a short illness. He leaves behind two sons, a reinvigorated field of particle physics and a clearer understanding of the forces that hold the universe together. ▮

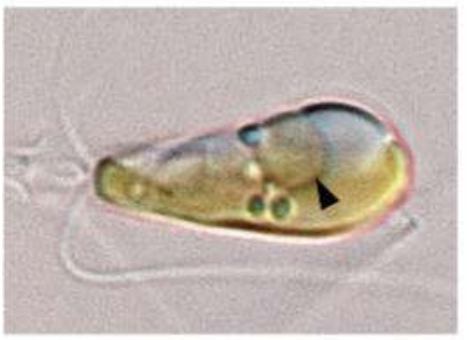
Evolution

Bacterium moves into an alga

A once-independent bacterium has evolved into an organelle that provides nitrogen to marine algal cells, an event so rare that there are only three other known cases, says **Michael Le Page**

IT WAS thought that in the 3.5 billion years since life first evolved on Earth, once-free-living bacteria had merged with other organisms on just three occasions, making this a very rare evolutionary event. Now, a fourth example has been discovered, in a single-celled alga found in oceans.

These algae were thought to "fix" nitrogen – convert atmospheric nitrogen into usable ammonia – with the help of a bacterium. Tyler Coale at the University of California, Santa Cruz, and his colleagues have now shown that this bacterium has evolved into a new cellular structure, or organelle.



TYLER COALE/UC SANTA CRUZ

A *Braarudosphaera bigelowii* cell, with a black arrow pointing to its nitrogen-fixing organelle

Beneficial relationship

This is the first known nitrogen-fixing organelle, or nitroplast, says Coale, and could be the key to the success of these algae. "It appears to be a successful strategy for them," he says. "These are very widespread algae. We find them all over the world's oceans."

It is quite common for one species to live inside the cells of another in a mutually beneficial relationship called endosymbiosis. For instance, cells in the roots of legumes such as peas host nitrogen-fixing bacteria. The success of cockroaches is partly due to endosymbiotic bacteria that produce essential nutrients. Some cells even host multiple endosymbionts.

While endosymbiotic relationships can be very close, in almost all cases, the organisms remain distinct. For example, legumes acquire their root bacteria from the soil. And while the cockroach bacteria are passed down in eggs, they live in specialised cells, not in every cell.

However, in three cases, endosymbionts have merged with their hosts to become a fundamental part of them. Energy-producing mitochondria arose from the merger of a bacterium with another simple cell, forming the complex cells that gave rise to animals, plants and fungi.

Plants arose when a cyanobacterium combined with a complex cell to form a chloroplast, the organelle that carries out photosynthesis. And about 60 million years ago, another cyanobacterium merged with an amoeba, forming a photosynthetic organelle called a chromatophore, found only in a few species of *Paulinella* amoeboids.

It has been suspected for more than a decade that a cyanobacterium known as UCYN-A living in the single-celled alga *Braarudosphaera bigelowii* has become an organelle. But studying the partnership was difficult until team member Kyoko Hagino at Kochi University in Japan found ways of keeping *B. bigelowii* alive in the lab.

As a result, the team could use a technique called soft X-ray tomography to watch what happens as the algal cells divide. This showed that UCYN-A divides in concert with the algal cell, with each daughter cell inheriting one UCYN-A. "We did not know how this association was maintained before this," says Coale.

The team also found that about half of the 2000 or so different proteins inside UCYN-A come from the algal host, rather than being made within UCYN-A (*Science*, doi.org/mq97).

Many of these imported proteins help UCYN-A fix nitrogen, says Coale. "I think it is being souped up by the algal cell to produce more nitrogen than it needs for itself."

There also seems to be a special system for delivering proteins to UCYN-A, as there is for other organelles. Imported proteins have an extra section thought to be an "address label" marking them for delivery to UCYN-A.

Although there is no universally accepted definition of an organelle, says Jeff Elhai at Virginia Commonwealth University, many biologists regard coordinated division and the importing of proteins as key.

"These are very widespread algae. We find them all over the world's oceans"

"Both boxes are checked," he says. "Even to the semantic purists, UCYN-A must be counted as an organelle, joining mitochondria, chloroplasts and chromatophores."

The manufacture and use of nitrogen fertilisers is a major source of greenhouse gas emissions, as well as an expense for farmers. So there is a lot of interest in modifying crop plants so they can fix their own nitrogen as legumes do.

One way to achieve this would be to equip their cells with nitroplasts, and Elhai has put together a proposal for how this could be done. But UCYN-A isn't a good starting point because it is too dependent on *B. bigelowii,* he says. Instead, Elhai envisages starting with cyanobacteria that have only just started down the road to becoming nitroplasts and don't rely on imported proteins, so they could be easily added to a wide range of crops.

Nevertheless, Elhai agrees with Coale that studying *B. bigelowii* could help us understand how to integrate nitrogen fixation into a plant cell. ▮

IPPEI NAOI/GETTY IMAGES

The *Braarudosphaera bigelowii* algae studied were taken from the sea off Nagasaki, Japan

Technology

Chatbots can persuade conspiracy theorists to change their minds

Chris Stokel-Walker

LARGE language model chatbots like those powering ChatGPT can reduce someone's beliefs in conspiracy theories by debating with them. The tactics used by the chatbots reveal potentially better ways for people to interact with conspiracy theorists.

Although research suggests that the number of people who believe in conspiracy theories hasn't changed substantially in the US or in Europe over about a decade, those who subscribe to such ideas have dogged faith in their views.

Many people try to counter this, but not always successfully. "Attempts to persuade conspiracy theorists [they are wrong] have historically not worked out very well," says Thomas Costello at the Massachusetts Institute of Technology. Now, he and his colleagues have come up with a successful approach.

They conducted an experiment with 2190 self-admitted believers in various conspiracy theories. The participants provided an outline of the case for a theory they subscribed to before being placed into a conversation with

JIM WEST/ALAMY

Satirical conspiracy theory Birds Aren't Real imagines that birds are spy drones

the artificially intelligent GPT-4 Turbo large language model (LLM).

The AI presented each person with a summary of their conspiracy theory and asked them to rate the level of confidence they had that the theory was true. They then had a chat with the LLM in which each side offered three contributions to the conversation. Next, the people were asked to put forward their case again and to once more rate their level of confidence in the truth of the idea.

Overall, belief in the specific theory they mentioned dropped by about 20 per cent on average, while the researchers also found a general decrease of belief in other conspiracy theories. The effect also lasted for at least two months, suggesting the AI had permanently changed people's views (PsyArXiv, doi.org/mrds).

"My hunch is that prior attempts to debunk conspiracy theories have been limited by how generalised they've had to be," says Costello. A broad, shallow engagement with facts often doesn't persuade conspiracy theorists, who tend to have read deeply into a subject, he says.

The AI model took a more rigorous fact-based approach: in 83 per cent of the conversations, it used evidence-based arguments for alternative perspectives, utilising its ability to synthesise large volumes of information. The AI also rarely deployed emotional appeals, so avoided invoking emotional responses that would hinder any persuasive power.

20%

How much belief in a conspiracy dropped after a chat with an AI

Costello believes the method could provide a model to counter conspiracy theories, either by using chatbots, or by having people mimic the AI approach. "In terms of the persuasive methods – being congenial, non-judgemental, focusing on facts – I think those are all things that humans would be able to do in theory." ▮

Archaeology

People in Australia made pottery over 2000 years ago

POTTERY fragments discovered on a remote Australian island are the earliest securely dated, locally produced pottery found in the country that pre-dates the arrival of Europeans.

The discovery on Jiigurru (Lizard Island), which lies nearly 35 kilometres from the Queensland coast in the Coral Sea, overturns the long-held belief that early Australians didn't produce ceramics or have the maritime technology to undertake long sea voyages.

Before this find, a mere 24 ceramic fragments were known in Australia, from islands in the Torres Strait, to the north. But from just this one excavation on Jiigurru, conducted in partnership with local Indigenous people, archaeologists found 82 shards of pottery.

Sean Ulm at James Cook University in Cairns, Australia, who led the research, says the team estimates that there are more than 130 cubic metres of archaeological deposits at the site. However, the team only excavated a 1-metre-square pit to a depth of 2.4 metres.

STEVE MORTON

A pottery fragment uncovered by an excavation on Jiigurru, or Lizard Island

Analysis of the fragments revealed the pottery was made from clays local to the island. While the pottery, some of which was decorated, was dated to between 2000 and 3000 years ago, the team found evidence that the site was occupied as far back as 6500 years ago (*Quaternary Science Reviews*, doi.org/mq94).

"That's thousands of years before it was thought that Aboriginal people had offshore voyaging capabilities of this type," says Ulm.

The dates, pottery and maritime technology needed to reach Jiigurru show that the islanders had seaworthy vessels and open-sea navigational skills and suggest they were connected with other pottery-making peoples across the Coral Sea region. ▮

James Woodford

Health

Treating your gum disease may prevent irregular heartbeat

Sonali Roy

GUM disease seems to increase the chance of an irregular and abnormally fast heart rate recurring after a procedure to correct the cardiac condition.

The heart condition, known as atrial fibrillation, can increase the risk of stroke or heart failure. In advanced cases, it can be treated via catheter ablation, a procedure that carefully destroys a damaged area of the heart that is interrupting its electrical circuits.

Now, Shunsuke Miyauchi at Hiroshima University in Japan and his colleagues have shown that gum disease may be a risk factor for atrial fibrillation.

The team enrolled 288 people who all had gum disease and who underwent ablation to treat atrial fibrillation. Of these, 97 received treatment for their gum disease up to three months later. This dental condition can be prevented by brushing with a fluoride toothpaste.

In the following two years, 24 per cent of participants experienced atrial fibrillation again, but this was 61 per cent less likely among those whose gum disease was treated after ablation. The risk of developing atrial fibrillation once more was higher if the gum disease was more severe (*Journal of the American Heart Association*, doi.org/mq96).

If gum tissue is inflamed or ulcerated then bacteria and inflammatory immune proteins can enter the bloodstream, which may affect the heart, says Miyauchi.

The researchers found elevated levels of inflammatory proteins in the blood of participants with severe gum disease before they underwent ablation.

The study was relatively small, so doesn't show a definitive link, says Nieca Goldberg at NYU Grossman School of Medicine in New York, but "it does set the groundwork for future studies in this area". ▮

Extraterrestrial life

Planets that look alike might be a sign of spacefaring aliens

Alex Wilkins

NEARBY planets that look unusually alike could be a sign of alien life that has travelled between stars, researchers have suggested.

Astronomers searching for extraterrestrial life tend to look for specific signals, either in the form of "biosignatures" – molecules that are only produced by biological processes – or "technosignatures", abnormal patterns of light that may have been produced by technologies.

Both of these rely on assumptions about how life might function on another world, which is largely based on our knowledge of life on Earth. However, this approach risks missing signals from alien life forms that might be very different to us.

Lana Sinapayen at the Sony Computer Science Laboratories and Harrison Smith at the Tokyo Institute of Technology, both in Japan, have proposed a new biosignature that doesn't rely on any specific molecule. Instead, it looks for similarities between planets in neighbouring star systems that life may have colonised. "We're trying to make very few assumptions about what this life looks like because we know nothing about what life, in general, could look like," says Smith.

1000
Number of planets contained in the studied universe simulation

Sinapayen and Smith started by assuming that life can spread between planets, either intentionally or by accident – an idea known as panspermia. They also assumed that it will somehow change the environment of the planets that it lands on, called terraformation.

The pair simulated a universe containing 1000 planets, each around a different star, with one planet that was sending out life in all directions. When life reached another planet, it would terraform it.

They then ran the simulation forwards in time to see which statistical patterns would appear between nearby groups of planets, irrespective of the kind of signal they were giving off, like a specific molecule or planetary temperature.

Based on this, they came up with a test to determine whether signals from a group of planets might contain life and a method to identify which planet in the group the life may have originated from (arXiv, doi.org/mrdk).

The study looks at an interesting combination of two possible ways that alien life may function, in panspermia and terraformation, says David Armstrong at the University of Warwick, UK. However, these mechanisms might not be possible, he says.

We may be able to spot planets that have been terraformed

PETER JURIK/ALAMY

Better telescopes

Even if terraformation were an option, it would be difficult to rule out the possibility that nearby planets had similar compositions for other, non-biological reasons, says Armstrong. "There's a couple of things there that I think would stop this being a 'one and done, we've definitely found life if we see this' kind of output," he says.

We will also need better telescopes to reliably start detecting molecules in exoplanet atmospheres, which would be required for this kind of similarity analysis, says Armstrong. "When we get to that stage, you'll be able to just look at lots of planets to try and find certain chemicals, so there'll be a lot of angles to explore there in terms of habitability." ▮

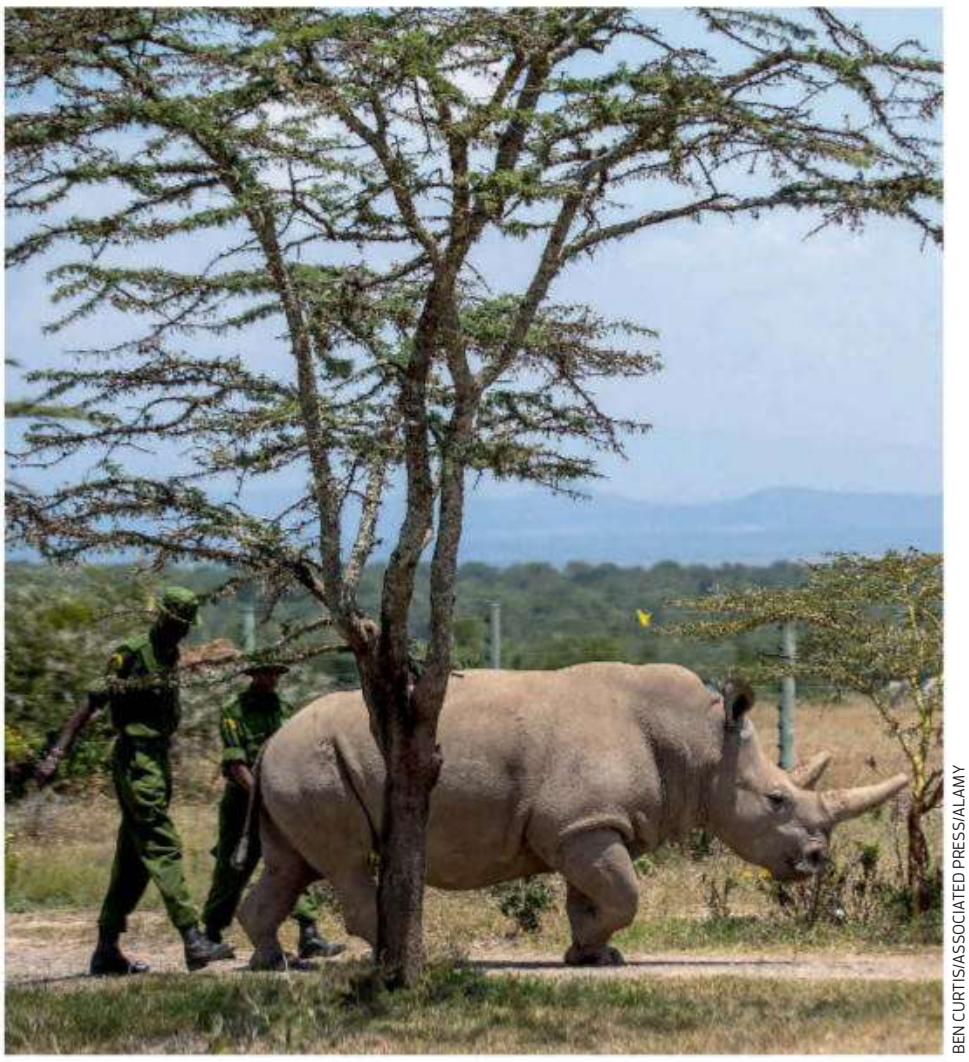
Medical technology

A better way to use bionic hands?

PROSTHETIC hands are usually designed to be operated by the same muscles that would be used if the person had their natural hand, but using unrelated muscles instead may lead to better control.

Hunter Schone at the University of Pittsburgh in Pennsylvania and his colleagues got 40 able-bodied people to undergo training over four days with the i-LIMB Quantum Hand prosthesis strapped to their wrists. Their corresponding real hand was bound so they couldn't move it.

People who had to manipulate the robot hand using unrelated muscle movements, such as those used to hold up one finger, took longer to work out how to control the hand, but seemed better able to learn to use it for new tasks *(Nature Human Behaviour*, doi.org/mq98). **Clare Wilson**



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Chemistry

Fractal seen at the molecular scale

A BACTERIUM has evolved an enzyme that assembles in a fractal structure, a mathematical pattern that repeats itself.

Fractal patterns have been found throughout nature on larger scales, such as in romanesco broccoli or fern plants, but hadn't been identified at the molecular level until now.

Georg Hochberg at the Max Planck Institute for Terrestrial Microbiology in Marburg, Germany, and his colleagues discovered the molecular fractal in an enzyme used by the cyanobacterium *Synechococcus elongatus* (*Nature*, doi.org/mq99).

In this organism, the enzyme, called citrate synthase, can arrange its building blocks into an unusual form of triangle that contains ever-smaller triangular gaps – a fractal pattern known as a Sierpiński triangle. **Alex Wilkins**

Conservation

Endangered white rhino could be saved by frozen skin

THERE are only two northern white rhinos left on the planet, but the species may be able to recover with the help of frozen skin cells from dead rhinos.

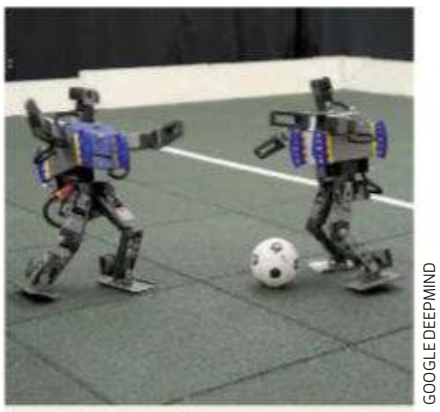
Much of the hope for the future of the northern white rhino (*Ceratotherium simum cottoni*) has rested on the last surviving members of the subspecies: Fatu (pictured above) and Najin, an infertile mother-daughter pair. Because neither can carry a pregnancy, conservationists are turning to genetic and reproductive innovation.

Now, Aryn Wilder at the San Diego Zoo Wildlife Alliance in California and her colleagues have looked at skin cells taken from 12 northern white rhinos and stored in their Frozen Zoo, a repository of genetic material from more than a thousand species. Using a computer model, they simulated how the subspecies would fare if the rhino genetic material was used to generate sperm and egg cells, which could then be turned into embryos and carried by females of the closely related southern white rhino (*Ceratotherium simum simum*).

They found it would be possible to restore the population and, after 10 generations, the northern white rhinos in these simulations were healthy and genetically diverse, rather than inbred (*Evolutionary Applications*, in press).

However, researchers would still need to chemically coax the frozen skin cells into viable sperm and egg stem cells and hope that southern white rhino surrogates can successfully carry the embryos of the northern white rhinos. Another way forward would be cloning: banked cells could be used to create a genetic copy of deceased animals. Corryn Wetzel

Really brief



GOOGLE DEEPMIND

Humanoid robots get football boost

Soccer-playing robots trained using deep reinforcement learning, which is driven by artificial intelligence, can walk 181 per cent faster, turn 302 per cent quicker, kick a ball 34 per cent harder and get up 63 per cent faster after falling than robots working off scripted lessons (*Science*, doi.org/mrbg).

Air pollution messes up fruit fly mating

When four species of fruit fly (*Drosophila* spp.) are exposed to levels of ozone gas comparable with those present on a hot day in a city, they are more likely to mate with the wrong species. The pollutant breaks down identifying scents the flies release (*Nature Communications*, doi.org/mrbc).

Turing award won for randomness

Mathematician Avi Wigderson has scooped the 2023 Turing award, often referred to as the Nobel prize for computing. One of his key discoveries was showing that certain algorithms that contained randomness and were hard to run could be made deterministic, or non-random, and easier to run.

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BAE SYSTEMS

Complexity beyond the battlefield

Securing Europe's freedom and prosperity will require the synchrony of organisations across the military, government, industry and academia. *New Scientist* invited a group of experts to discuss how complexity science might help

"Defence is a truly complex, multifaceted business," says Nick Colosimo, an engineer and technologist at the international defence company BAE Systems. "There's complexity in the physical equipment and digital systems we make, in the supply chain that helps make them and we how provide support. Rarely does a ship or aircraft operate on its own. They always operate as part of a vast and complicated system."

An important challenge in conducting NATO operations on land, sea and air, as well as in space and cyberspace, is to get all the many parts of these systems working together. And as security becomes more multifaceted, this also involves government departments, intelligence services, industry, research and development organisations, academia and universities. "We need all that to achieve something greater than the sum of the parts," says Colosimo.

In NATO terminology this is called "multi-domain operations". In making it work, NATO faces a challenge well known to modern science: that of understanding and managing so-called complex systems.

These are systems that naturally evolve and adapt to the environment around them, examples include ecosystems, economies or living organisms. The collective behaviour of such systems cannot typically be deduced by understanding the parts because they emerge from the delicate interactions between these components. As a result, complex systems are difficult to predict and prone to sudden, dramatic shifts from one regime of behaviour to another. They are also often surprisingly resilient to disturbances.

A major theme in the study of such systems is that lessons learnt about one complex system can help understand others. The study of ecosystems, for example, yields insights into economies and large-scale computer networks.

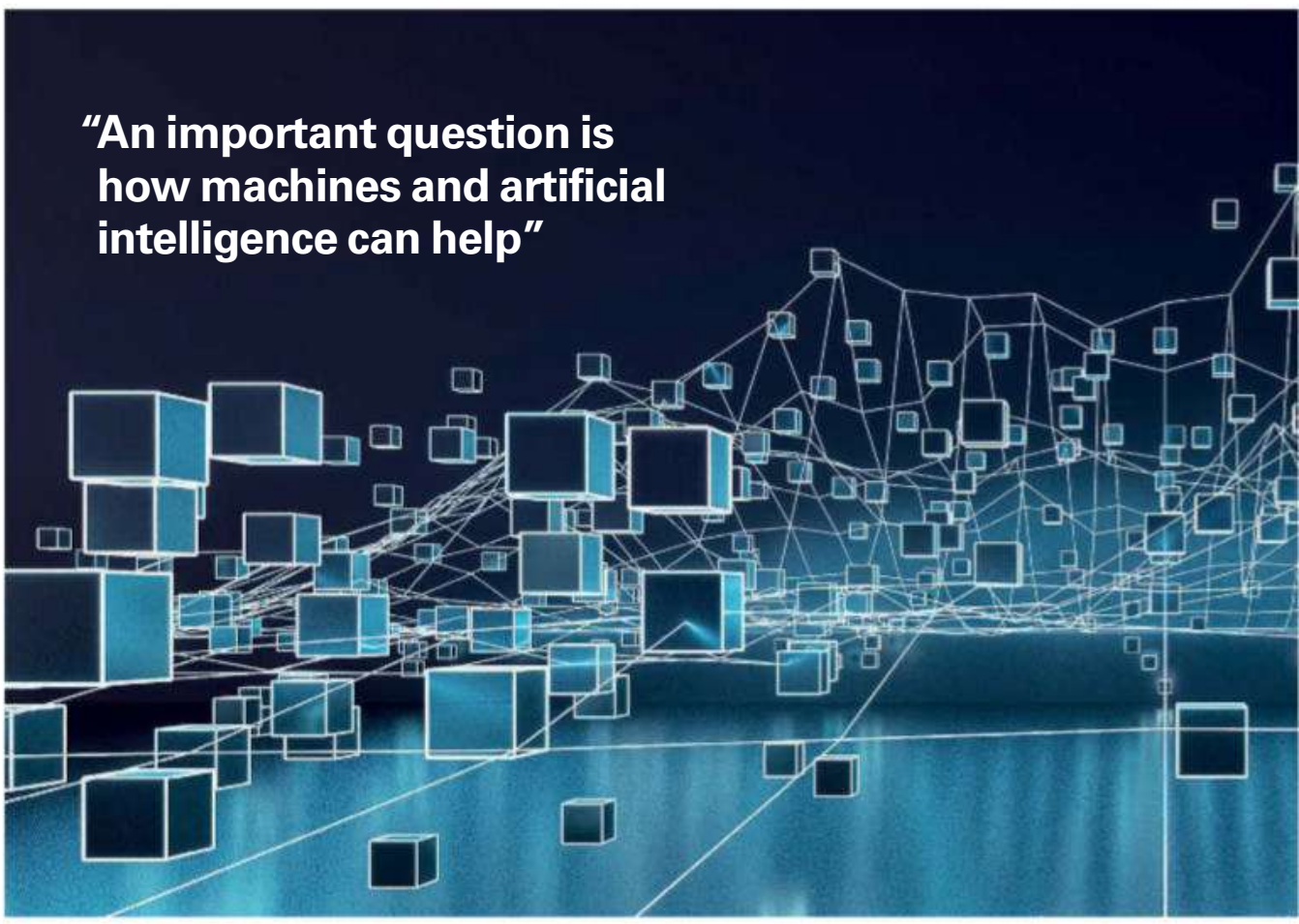
That raises the question of whether the patterns of complexity in fields such as economics, pure maths and computer science can inform how we make sense of the data challenge of multi-domain operations. So last month, a small group of experts from industry, the Ministry of Defence and complexity science came together to discuss this challenge during a New Scientist workshop sponsored by BAE systems.

For Gordon Niven, a specialist in systems thinking at the Defence Science and Technology Laboratory at Porton Down, a key obstacle in adapting defence systems to rising complexity lies in the military's relatively fixed and structured relationships and ways of working. This has facilitated large-scale industrial warfare against a well-defined enemy for over a century.

But the nature of warfare is changing. The military now confronts more diverse adversaries, in groups of many sizes and motivations, often not associated with nation states.

So-called grey zone warfare can also be carried out through alternative means, for example via cyberspace, through the spread of propaganda and even by the weaponisation of human migrations. Add to this the explosive growth of activity in space, under the sea and the emergence of autonomous vehicles and other agents.

In this new high-complexity setting, leaders need to digest vast volumes of information from numerous operational domains, some of which may be untrustworthy. The military must also cooperate with other military and non-



Workshop experts:

Nick Colosimo
BAE Systems

Weisi Guo
Cranfield University

Kerstin Hötte
The Alan Turing Institute

Henrik Jeldtoff Jensen
Imperial College London

Gordon Niven
Defence Science and Technology Laboratory

Jeremy Pitt
Imperial College London

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military organizations with different traditions and practices.

"The military has not evolved as rapidly as its operating environment," says Niven. Military headquarters have become larger to deal with the increasing diversity of tasks. "But this makes them less efficient, less effective and less mobile. Also more vulnerable," he says.

But neither can the military easily shift itself to more complex settings, says Niven. "The military has actually got to work across the entire spectrum of operations because they still have to do industrial warfare," he says. "But they also have to be capable of operating in complex situations."

That requires new ways of thinking. Henrik Jeldtoff Jensen, a mathematical physicist at Imperial College London, points out that a key feature of complex systems is that they are indivisible wholes. The operation of any subsystem only makes sense in the context of its connections to the rest. An economy, for example, cannot be analysed without understanding its components, its relations to other economies, as well as its dependence on the underlying Earth ecosystem.

This suggests that global thinking will be crucial in producing insightful pathways to multi-domain operations. Even NATO is part of a larger network, which includes not only its many allies, but also its adversaries.

One complication for NATO is the sheer scale of the system in question and the vast amount of information associated with it. The military is learning how to gather data on increasingly larger scales. But more is not always better. "What they need is the right sort of information about the right things at the right level of abstraction," says Niven.

An important question is how machines and artificial intelligence can help. Weisi Guo is an expert on human machine intelligence at Cranfield University. He and colleagues have processed carefully chosen data on a global scale to model and predict the outbreak of peace and conflict one year in advance with over 90 per cent accuracy.

Guo and colleagues used a simple model in which a specific region is either at peace or in conflict. They then used machine learning to study the factors influencing the likelihood of a change in this status. In general, the team found that the absence of long-term trading relations with neighbouring regions is a good predictor of the emergence of violent conflict in the near future. This may be particularly important as the military increasingly plays diverse roles not only in direct combat, but in peacekeeping, natural disaster relief and in interventions to avoid conflicts escalating.

Gathering better data on human behaviour and interactions will help, says Kerstin Hötte, a researcher in finance and economics at The Alan Turing Institute. This would accelerate our ability to run more accurate simulations and to explore multiple ideas about more flexible and adaptive system organisation at low cost, without putting anything at risk.

Other complex systems can also provide valuable lessons. Jeremy Pitt, a specialist in intelligent and self-organising systems at Imperial College London, pointed to long-standing research on social dilemmas, and the diverse mechanisms humans have invented to engineer and support cooperation. Some of these could be adapted to apply in the complex military systems setting in which autonomous machines interact.

Yet, as Niven concluded, achieving better management of complexity in NATO operations will still be difficult. Real world complex systems generally emerge through an evolutionary process of learned adaptations to past events. A similar approach for the military – experimenting with new practices to see which work and which do not – is not an option.

Small-scale exercises can help but are generally expensive. An alternative is to run tests through large-scale computational simulations meant to mimic military operations, where AI can model increasingly realistic scenarios. The problem, as many participants agreed, is that it is unclear just how accurate such simulations can be.

Somehow, NATO must find a way to test and validate new ideas and that will be hard. However, by sharing ideas around how other academic disciplines model complexity and by keeping military experts closely involved, there could well be progress in future.

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Comment

The other energy crisis

One in five adults worldwide is living with fatigue. We need to change the way we think about exhaustion, says **Amy Arthur**

THERE can be no doubt that we are in a time of crisis when it comes to our use of the planet's limited energy resources. We have to leave our bad habits in the past and focus on more sustainable solutions. But while we are rightly concentrating on Earth's delicate energy balance, we are ignoring the signs that our own bodies are running on empty.

Writer and computer scientist Cal Newport has called this the era of "The Great Exhaustion". The pandemic sent stress levels skyrocketing and drained people in unique ways, some through emotional exhaustion and burnout, others via loneliness, grief or anxiety. Four years on, things are no better. According to a 2023 meta-analysis, one in five adults worldwide is living with fatigue unrelated to a medical condition.

There are many reasons someone might feel tired all the time, such as a poor diet, lack of physical activity or a deficiency in a particular nutrient. Mental health conditions, including depression and anxiety, can also lead to feeling exhausted or apathetic. In a few cases, something more sinister is going on: extreme fatigue can be an early warning sign of cancer, for example. But there are plenty of healthy people, eating well and exercising weekly, who feel burned out by the demands of life.

Current advice to keep fatigue at bay is almost always to "do more". The idea seems to be that one can push through exhaustion by sheer will without repercussion. Top of the list of things you can do to help on the UK National Health Service's page for "tiredness and fatigue", for example, is to "have a healthy diet and exercise regularly".

ELAINE KNOX

But fatigue itself can perpetuate the conditions in which it thrives: 35 per cent of UK adults say that being "too tired" holds them back from having a healthier diet and doing more exercise. How can people put effort into finding, planning and cooking new recipes if their existing lifestyle leaves them without any spare energy? How can someone find the time to go to the gym or attend a fitness class when every moment of the day is already allocated by work, school, kids, housework, the admin of life...

This isn't to say people in general don't need to eat well and keep physically active. But "do more" isn't the only solution to our exhaustion epidemic. Instead, we need to "do different" or "do smart". For example, if you feel incapable of dealing with all of life's demands, swap the unnecessary for the achievable.

A 2018 study showed that burnout and exhaustion are often marked by a lack of confidence in one's ability to meet goals, face challenges and produce good work. If eating healthier and exercising more feels impossible, being told to do these things might only lower your belief in yourself further. To counteract this, focus on doing something you know you are good at. For me, this means taking my camera with me when I go out, something I don't do often enough.

Importantly, don't use all your energy on the stuff you have to do. If all your time is spent working, cleaning or looking after your own or others' health, you will miss out on the benefits of recreation. And when work takes over your free time, research has shown that it leads to reduced vigour and lower overall well-being.

It is time we stop avoiding the uncomfortable truth that it is our misguided ideas about energy that have got us to this point. Just like our planet, our energy supplies aren't inexhaustible and we need to break our bad energy habits.

We have come to see how reliance on fossil fuels is unsustainable and dangerous for the future. Now we must acknowledge that burning through our own energy supplies makes us stressed and exhausted today, and more at risk of serious health conditions later. ▮

Amy Arthur is the author of *Pace Yourself: How to have energy in an exhausting world*

Our human story

Welcome to the team

Five years ago, our extended human family got a bit bigger with the announcement of a new species of hominin. What have we learned since, asks **Michael Marshall**

Michael Marshall is a science writer based in Devon, UK. He writes *New Scientist*'s monthly email newsletter Our Human Story, about human evolution. His book *The Genesis Quest* is about the origin of life on Earth and is now available in paperback

Michael's week

What I'm reading
The entire first half of Brian K. Vaughan and Fiona Staples's epic graphic novel Saga. *Now I want them to hurry up and finish the second half.*

What I'm watching
The final season of Star Trek: Discovery.

What I'm working on
A half-dozen disparate projects, the combination of which is causing my brain to leak out through my Eustachian tubes.

Annalee Newitz will return next month

ON 10 April 2019, a study reported the discovery of a new species of hominin called *Homo luzonensis*, from the Philippines. Five years on, I think it is a good time to revisit the story, to see what else has emerged.

The *H. luzonensis* remains were found in Callao cave on Luzon, the largest island in the Philippines. The first fossil, a foot bone, was discovered in 2007 by a team co-led by Florent Détroit at the French National Museum of Natural History and Armand Salvador Mijares at the University of the Philippines. It wasn't clear what species it belonged to. But 12 years on and the team had 12 more fossils: seven teeth, two finger bones, two toe bones and part of a thigh bone. Dating studies suggested some of the remains were 50,000 years old.

This was enough for the researchers to declare this a new species. The bones didn't match those of our species, nor did they map onto any other known hominin. So which hominins were the progenitors of *H. luzonensis*?

This question is tricky. Luzon has a tropical climate, so it is unlikely ancient DNA has been preserved – attempts to extract it from the remains have been unsuccessful. We only have one set of remains of *H. luzonensis*, so we don't know how long they lived on Luzon. A 2018 study found the earliest known hominin activity in the Philippines on Luzon, in the form of stone tools and butchered rhino bones, dating to 709,000 years ago. Conceivably, the hominins involved were *H. luzonensis* or their direct ancestors, but no hominin bones were found so we can't know.

This means a wide variety of hominins are in the frame. One candidate is *Homo erectus*, which was living outside Africa at least 1.8 million years ago and survived at Ngandong on the Indonesian island of Java until as recently as 108,000 years ago. It seems distinctly possible that some *H. erectus* made it to Luzon.

Another possibility is the "hobbits", *Homo floresiensis,* known from the island of Flores in Indonesia. It is conceivable that some of them made it to Luzon and then became isolated there. However, there is no sign of the hobbits outside Flores. The timings also may not work: the hobbits probably lived on Flores between 190,000 and 50,000 years ago, so if *H. luzonensis* turns out to be older than that, the hobbits can't be their ancestors.

"The most dramatic possibility is that *Homo luzonensis* is directly descended from an *Australopithecus*"

The third possibility is the Denisovans, whose remains have been found on mainland Asia in the Altai mountains and on the Tibetan plateau. Today, many people on the islands of South-East Asia carry Denisovan DNA, and a 2021 study found groups called Ayta living on Luzon have the highest level of Denisovan ancestry in the world, hinting that the Denisovans visited the island.

Finally, there is the most dramatic possibility: that *H. luzonensis* is directly descended from an *Australopithecus*. These earlier hominins have only been found in Africa, but it is possible some of them did wander outside the continent. In the original 2019 study, the researchers described a number of attributes of the *H. luzonensis* remains that aren't found in other *Homo* species but are present in *Australopithecus*.

The evidence in favour of *H. erectus* ancestry includes a 2022 study from Détroit, Mijares and their colleagues. They compared the teeth of *H. luzonensis* with those of other hominins. The crowns were most like those of *H. erectus* in their external shape, while the internal structures were most similar to those of *H. erectus* and of hobbits. The team interpreted this to mean that both *H. luzonensis* and *H. floresiensis* were descended from *H. erectus*.

But in 2023, the researchers released another tooth study, yet to be peer-reviewed. They measured the layers of cement on the teeth, which are laid down yearly. This suggested that one of the *H. luzonensis* individuals died age 31, or perhaps a little older. It also hinted that they had shorter childhoods than modern humans, more like those of chimpanzees.

This could fit with the fact that some of the *H. luzonensis* remains are pretty small, so they may have been small – in which case it wouldn't take them too long to reach maximum size. It could also be evidence of a link with *Australopithecus*, more ape-like than any *Homo* species.

The *Australopithecus* idea is the most radical and the one that excites me the most. Nevertheless, I am wary. Yes, the similarities are there, but evolution often throws up the same thing multiple times in different species.

The other issue is that we have plenty of evidence of *H. erectus* in South-East Asia and no physical evidence of *Australopithecus* outside Africa. For that reason, I think *H. erectus* remains the most likely ancestor of *H. luzonensis*. But never say never. After all, nobody in the 20th century was predicting *H. luzonensis* or the hobbits, yet here we are. ▮

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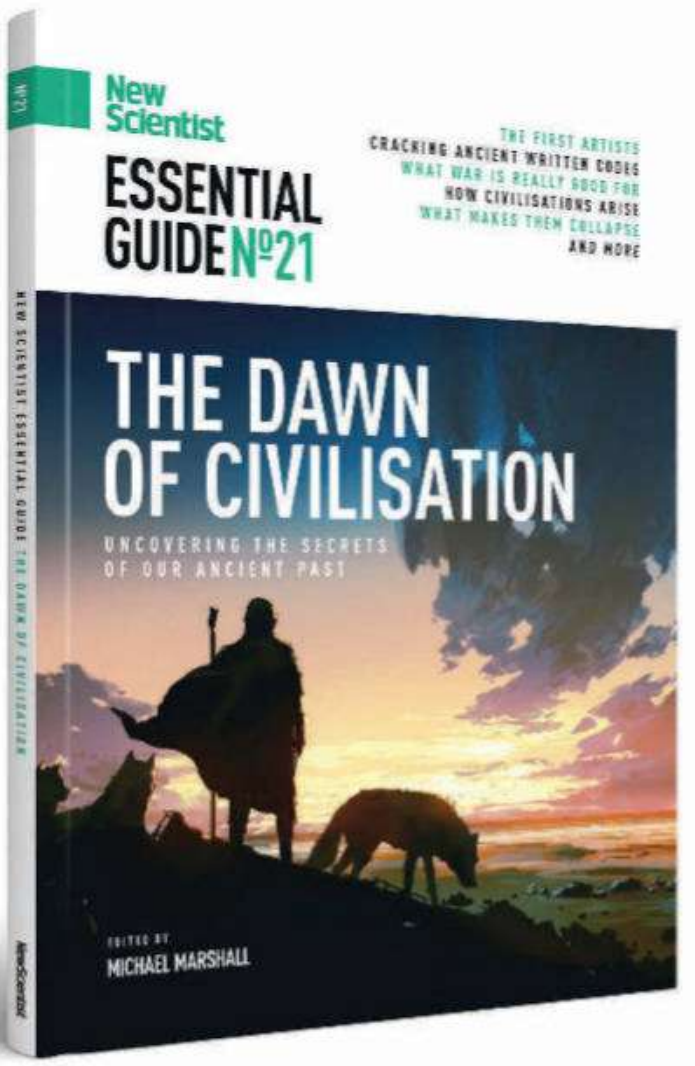

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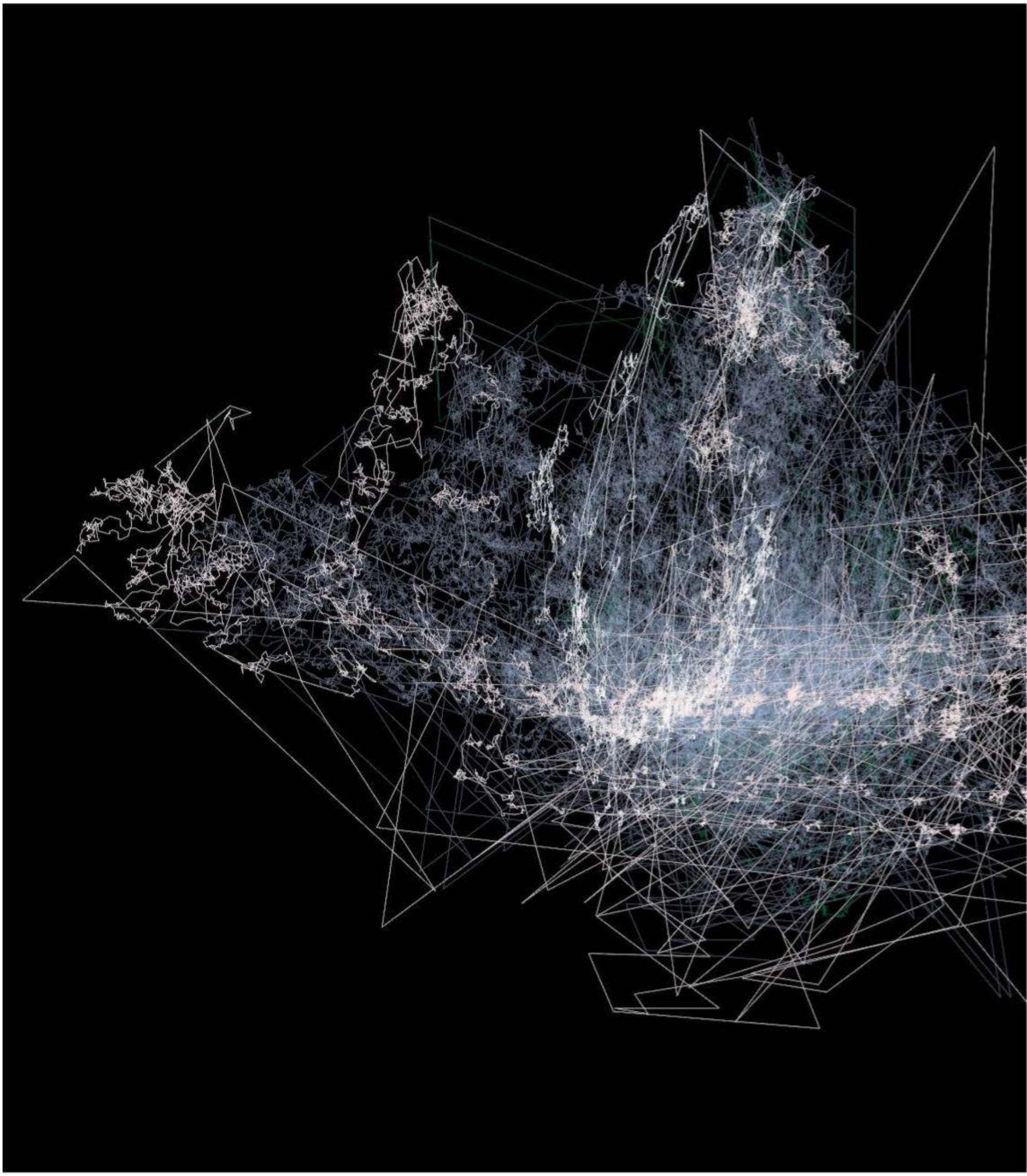

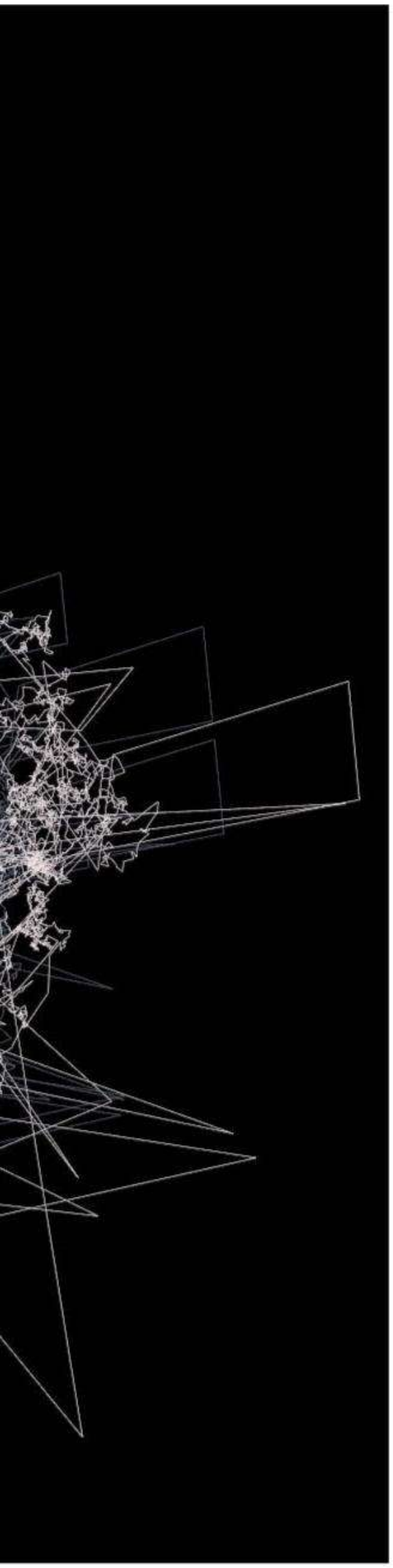

ELYSE TONNA

Ghost ships

Matthew Attard
Galleria Michela Rizzo

AT THE 60th Venice Biennale, Maltese artist Matthew Attard addresses his country's maritime heritage, along with notions of faith and progress, through the prism of AI-driven technology. His work focuses on images of ships that were graffitied by seafarers on the stone facades of chapels in Malta between the 16th and 19th centuries, one of which is shown at near left, bottom.

Attard, pictured, retraced the incised lines of the hulls, rigging and billowing sails using his gaze, in a process facilitated by an eye-tracking device and generative algorithms. "This gaze was translated into data points by the technology, which were then further interpreted to generate lines or drawings," he says.

A database of digital images generated from the data points captured the engravings from various perspectives, from which artworks such as 3D scans and video pieces were created.

The maritime graffiti resonates with cultures whose relationship with the sea has been – and still is – crucial, where the ship remains a metaphor for hope and survival. Similarly, Maltese chapels have long been places of sanctuary. Attard says he wanted to explore "parallels with our current 'blind faith' in digital technology".

His reinterpretations of the etchings are ghostlike, skeletal impressions, as shown in the main image. "One could argue that even the most traditional mediums, such as a pencil or a piece of charcoal, can be considered a form of drawing technology," he notes. His show is at the Malta Pavilion at the Venice Biennale, Italy, commissioned by Arts Council Malta, until 24 November.

Christian House

The hypochondria challenge

Millions of people experience symptoms many doctors dismiss as imaginary, but why? A moving first-person account is very revealing, finds **Elle Hunt**

Book

A Body Made of Glass

Caroline Crampton

Granta

ARTHUR TREES/SCIENCE PHOTO LIBRARY

The distinction between "real" and imagined illness is under debate

PICTURE someone with hypochondria. It may be a friend who keeps an inventory of symptoms and ailments, is never without a doctor's appointment and turns up armed with the latest from Google. Some doctors label such people disparagingly as the "worried well", those whose demand on medical services is seen to outweigh their need.

But a new book challenges that derogatory and outdated view of hypochondria – now more commonly known as health anxiety in response to the stigma – in favour of one that is more compassionate and better reflects the slippery boundary between body and mind.

A Body Made of Glass: A history of hypochondria by journalist and podcaster Caroline Crampton is billed as the first social history of this form of anxiety, tracing the condition back to Hippocrates in the 5th century BC. The popular, long-standing comedic treatment of hypochondria, such as in the work of French playwright Molière and films directed by Woody Allen, has contributed to the shame and stigma dogging the condition and those who experience it.

Crampton's title refers to a peculiar phenomenon in late 14th- century Europe when people began visiting doctors in the belief that they were made of glass, "a fitting touchstone", she says, "for the complex knot of emotions and sensations" that make up our experience of good and poor health.

These days, we increasingly understand that mental health affects physical health and vice versa, such as via the gut microbiome and the impact of emotional trauma on the body – often making it difficult or even futile to distinguish between "real" and imagined illness.

While health anxiety may well be defined and sometimes dismissed as involving imaginary ailments, the associated distress is undeniable – and can even be deadly. A recent study by a team at the Karolinska Institute in Sweden found that people with health anxiety had a higher risk of death, dying five years younger on average than those without the condition – mainly from potentially preventable causes.

"If we are convinced that we are sick, what difference does it make if no condition can be found?"

Alongside her exhaustively researched cultural history of health anxiety, Crampton's own experience illustrates the personal anguish involved. At the age of 17, she was diagnosed with Hodgkin lymphoma. After chemotherapy, she remained attuned to changes in her body, as she was advised to do by her doctors. Her vigilance was warranted: she eventually found a lump in her neck, necessitating more chemotherapy.

At 22, Crampton was declared cured – but her anxiety persisted. For over a decade, she lived in a "twilight zone between illness and health", compulsively checking for tumours and leaping to worst-case scenarios. Naturally, this anxiety negatively affected her well-being beyond verifiable issues with her physical health.

Crampton's moving description of the toll should check those inclined to dismiss her as neurotic. She is terrified of wasting doctors' time. Her history of cancer means even the slightest reports are investigated. Crampton was once referred to a neurologist after mentioning a feeling of pins and needles. With wry humour, she recognises the frequent absurdity of her situation: "I sometimes wish I was taken less seriously."

She is an evocative writer, capable of elegant description and astute analysis, and she captures the ambiguities and contradictions of health anxiety. As in Crampton's case, it is often triggered by verifiable physical conditions and exists alongside them, complicating the popular perception of health anxiety being about strictly imaginary ailments.

The authors of the Swedish study likewise concluded that a possible explanation for the increased mortality of people with health anxiety could be the impact of living with the chronic stress of the condition.

In *A Body Made of Glass*, Crampton sets out to chase this condition through history. She not only succeeds, but ends up posing intriguing and potentially important questions. If a cure leads to complications, or to a new and different illness, can it still be considered a cure? If a treatment alleviates our distress (as the still-controversial eye movement desensitisation and reprocessing trauma therapy treatment did for her), does it matter if it doesn't pass muster scientifically? And if we are convinced that we are sick, what difference does it make if no condition can be found? ▮

Elle Hunt is a writer based in Norfolk, UK

Everything but the truth

Can you see through deceiving data and beguiling stories? Take the card test and find out, says **Chris Stokel-Walker**

Book

May Contain Lies
Alex Edmans
Penguin Business, 25 April (UK); University of California Press, 14 May (US)

HERE is a logic puzzle. You have been given four double-sided cards, each with a number on one side and a letter on the other. You are told to test this: "If a card has a vowel on one side, it has an even number on the other side." The cards, as dealt, read "E, K, 2, 3". Which do you turn?

If, like me, you decided on E and 2, then you need to read Alex Edmans's book, *May Contain Lies: How stories, statistics and studies exploit our biases – and what we can do about it*. Answering E and 2 supports the rule but doesn't probe its accuracy. Turning E and 3 proves the positive as well as disproving the negative – the correct answer.

Or, as the professor of finance at London Business School puts it elsewhere in his book: "But becoming more knowledgeable and making better decisions isn't just about defending against misinformation – it's also about positively gathering information."

Edmans is out to help us better understand and analyse the data we are fed, and to aid us in becoming more sceptical. He shows us how data has been misrepresented in the past and how initiatives have been launched on the back of bad information. "Data is just a collection of facts," he writes. "Evidence is data that allows you to distinguish between hypotheses – to support yours and rule out alternatives."

Some of his examples are far-reaching. He explains how parents began foisting instruments on young children following the publication of Malcolm Gladwell's *Outliers*, with its proposal that you can become an expert at anything if you devote 10,000 hours to it. The truth, as he discovered, is complex. Other stories are more personal. One investor approached Edmans asking him to identify metrics showing that more diverse companies achieved better financial returns – only to abandon him and choose a competitor who was willing to make the facts fit the narrative when Edmans wasn't.

He also issues a rallying cry for rationality designed to prebunk the sort of article or book (common in the business world) that tries to stitch a neat narrative onto the successful outcome of a magnate such as Steve Jobs. We need, he says, to know how to spot such false claims before we encounter them.

Edmans outlines how two different descriptions of Apple's success contradict each other and yet are similar: both prey on black-and-white thinking, play into confirmation bias and have an engaging narrative. Stressing that "we forget the basic scientific method when we're told a compelling story", Edmans aims not just at journalists but at myriad TED talks, as well as foreshadowing "factual" communication through TikTok, where people can add facts haphazardly to fit a predetermined narrative and go viral.

The author himself has been subject to such spin, as he recounts. He submitted a detailed, well-researched document to a UK parliamentary inquiry on wage disparities, as well as appearing in front of the committee, only to find his evidence misrepresented to say the opposite of what he had outlined in his final report.

His point is compelling. But it also means that Edmans is unwilling to put story before statistics. In its place, he relies on a "Ladder of Misinference". This diagram shows how decision-making can go wrong, with the apparently sturdy rungs from "statement" to "evidence" actually open to question.

Luckily, two-thirds of his book is a page-turner. And the appendix ("a checklist for smarter thinking") should be required reading – because too many people are going to choose the wrong cards.

Chris Stokel-Walker is a writer based in Newcastle upon Tyne, UK

Facts communicated over social media are often made to fit an existing narrative to go viral

CAROL YEPES/GETTY IMAGES

New Scientist *recommends*

Sofia Stefanakis
Student
London

I'm loving **The Emperor of All Maladies** by Siddhartha Mukherjee, an engrossing history of cancer that spans the millennia from ancient Egypt to the modern day. Mukherjee

sets his own life as an oncologist at Massachusetts General Hospital against this historical backdrop, creating both a stunning insider account of one of the world's biggest killers and a compelling story of human resilience, filled with moving patient experiences.

I've also been enjoying the fourth season of **For All Mankind** (pictured), an alternative history series where the Soviet Union is first to land on the moon. Everything changes as the US rushes to catch up.

By 2003, humans are established on Mars, and the new season sees an international coalition collaborating with Helios, a private company, as it works to push an asteroid back into Mars's orbit to harvest crucial minerals.

Think heists, sabotage, interplanetary smuggling and more. Be prepared for a tense season finale!

JESSICA BROOKS/APPLE TV+

The TV column

A jaunty trip to the apocalypse

Amid a deluge of dour shows about the end of the world, *Fallout*, based on the hit video games of the same name and set in the wastelands of 2296, stands out for being a lot of fun, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on Twitter @inkerley

JOJO WHILDEN/PRIME VIDEO

Lucy (Ella Purnell) leaves her bunker to face life on the perilous surface

IF YOU have read this column before, you may have seen me declare my apocalypse fatigue, what with the sheer volume of doomsday drama on TV today. I still am fatigued, for the most part, but a new series from *Westworld* creators Jonathan Nolan and Lisa Joy has given me pause. Based on the hit video games of the same name, Amazon Prime Video's *Fallout* is a jaunty, free-wheeling trip to the end of the world, far from the dour survival dramas dominating our screens.

Fallout conjures up an alternate history drenched in Americana. Before the Great War of 2077, the US was a nuclear playground where the 1950s never really ended. With household robots to perform chores, the wealthiest members of this retrofuturistic society had more time to knock back a Nuka-Cola and brood over impending annihilation – or, worse still, communists infesting Hollywood. The apex of this jingoistic, hyper-consumerist culture was Vault-Tec, a company hawking underground bunkers to those with sufficient wealth to buy an apocalypse-proof shelter.

When judgement day finally came, the elites scurried underground and left the world to burn. But the destruction wasn't total: pockets of survivors eked out an existence on the ravaged surface. Radiation turned some into ghouls, mutated posthumans capable of living for hundreds of years if they could avoid going feral. (A disclaimer: *Fallout* is as far from the realism of hard sci-fi as it is possible to get. Don't expect an explanation – you won't get one.)

"A disclaimer: *Fallout* is as far from the realism of hard sci-fi as it is possible to get. Don't expect an explanation"

Our story picks up in the hardscrabble wasteland of 2296. Led by Hank MacLean (Kyle MacLachlan), a now-egalitarian community of apocalypse dodgers lives in comfort deep below the ground, intent on rebuilding civilisation within a generation.

Hank's daughter Lucy (Ella Purnell) is a chipper young woman happy to be married off to a stranger from a neighbouring bunker. But when her wedding descends into violence, Lucy must ascend to the surface world in search of her kidnapped father. In this ultraviolent frontier, populated by cowboys and cannibals, her generosity of spirit won't get her very far.

The first episode of this eight-part series is a little clumsy, burdened as it is with the need to introduce *Fallout*'s lore and darkly comic tone. But when Lucy hits the not-so-fresh air above ground, something clicks into place, especially once she is in contact with rogue scientist Wilzig (Michael Emerson).

He is on a secret mission, but the price on his head has attracted the wasteland's warring factions, including The Ghoul (Walton Goggins), a gunslinging bounty hunter who becomes our window into the pre-war past. Rounding out this trio is Maximus (Aaron Moten), an acolyte of a religious paramilitary group that seeks out pre-war technologies. Moten is a star in the making: he plays Maximus like a traumatised child, but also with great humour.

Amazon has clearly bet big on *Fallout*. It also aims to please fans of its source material. For instance, I was delighted to see Wilzig has a canine companion (dogs feature in the games) and to hear many of the 1950s hits that helped keep players pinned to their consoles. *Fallout*'s all-American apocalypse has lots to say about capitalism and the supposedly benign forces of civilisation. But it is also just good fun – something we need more of on our TV screens. ▮

TV
Fallout
Jonathan Nolan and Lisa Joy
Amazon Prime Video

Bethan also recommends...

TV
Westworld
Jonathan Nolan and Lisa Joy
HBO
Based on the 1973 film, this series is set in a frontier-themed amusement park full of ultrarealistic robots that can be killed and tortured with impunity – until they start to become sentient.

TV
Black Sails
Neil Marshall
Amazon Prime Video
This Treasure Island *prequel might not seem an obvious companion to* Fallout*, but it is a stunning exploration of who is granted access to the privileges of civilisation.*

Editor's pick

How to handle the demographic storm

30 March, p 13

From Stephen Johnson, Eugene, Oregon, US

Falling birth rates will bring many social and economic problems, but are absolutely necessary for the environmental health of the planet. Loss of habitat, ocean pollution, carbon emissions and many other environmental problems have accelerated in step with population growth. With population decline, we must shift from an economic model that requires continual growth to one that rewards a shrinking economy. In addition, individual consumption must be cut. To the extent that artificial intelligence and robotics reduce the need for human labour, it will be possible to produce all we require with a shrinking workforce.

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

Surely the problem of greater numbers of older people needing to be supported in every way by diminishing numbers of younger people will be a transient one. As more-populous older generations die off in the next few decades, they will be replaced by smaller, later generations and, in a relatively short time, a new equilibrium will be established. There will be problems, but we can find ways to deal with them.

From Sadie Williams, Lancaster, UK

I can easily envisage a world of healthy, happy older people where everybody is active and works until they are 80 and old age is seen as being in your 80s and 90s. The hard physical work would, of course, have to be done by younger adults, with help from robots, but the less arduous physical tasks could easily be done by those in their 60s and 70s. Children would be less common and resources now devoted to schools and teacher training could be diverted into care for older people. Such a society would surely be no worse than our own.

Defining the impact of ecocide on our minds

6 April, p 36

From Paul Fink, Natalia, Texas, US

Eco-anxiety is a new concept, but it is closely linked to another known as solastalgia, which *The Lancet* included in 2015 as a term related to the impact of climate change on human well-being. It defines the set of psychological conditions that occur in a population after destructive changes in their territory, whether as a result of human activities or the climate.

Another explanation for phone-related anxiety?

Leader, 6 April

From Roberta Orchard, Keynsham, Somerset, UK

Could it be that parental overuse of smartphones, rather than their use by children, has something to do with the increase in anxiety in young people? There is a lot of evidence that attuned noticing by and interaction with attachment figures is crucial to child development and mental health. Parents matter more than school, peers or therapists to the well-being of children.

Solitude brings the best solutions to problems

30 March, p 32

From Geoff Harding, Sydney, Australia

You highlight the benefits of time alone. I have found that if you have a problem that requires thought and analysis, solitude is often your best friend. In my career, the best ideas and solutions occasionally arose in conversations with colleagues, but more frequently during a period of solitude, whether in an office, at home or during a long walk.

Language is surely a factor in long human childhood

30 March, p 36

From Stein Boddington, Sydney, Australia

Focusing on the physical palaeo-anthropological record in the story of how human childhood and adolescence became so prolonged neglects what is perhaps the lengthiest task a child has: mastering language. It takes around 20 years for an acceptable competence to embed itself in the neuro-architecture of our brains and to acquire enough factual and conceptual knowledge to be able to function well in the adult world.

On the many weird theories of reality

23 March, p 32

From Brian Reffin Smith, Berlin, Germany

I propose that, on some bizarre-but-possible meta-level, all the weird theories of quantum mechanics, panpsychism and simulated realities that Eric Schwitzgebel lists exist and are simultaneously useful. All are true, all are bizarre and all are dubious. We probably won't ever be able to "choose" between them anyway since they are, on a level we can't comprehend, the same thing. This may sound daft, but this many-theories hypothesis describes the present state of things well and is no worse than anything else.

From Wolf Kirchmeir, Blind River, Ontario, Canada

If we accept that our experience of reality is a simulation created by our brains, then the "self" must be part of the simulation. To ask whether we live "in" a simulation is a category error. We live as a simulation, not in one.

From Mike Hawkins, Bolsover, Derbyshire, UK

Quantum and wave mechanics, together with relativity, were developed to explain physical phenomena that had otherwise defied explanation. They have been spectacularly successful at describing particle/wave properties and behaviour, which is what they were intended to do. It really comes as no surprise that trying to extract sense from these mathematical constructs about more complex "fundamental reality" leads to bizarre, untestable hypotheses. Perhaps we should simply acknowledge that these theories cannot, in fact, tell us anything useful about fundamental reality.

Our mental blinkers are even more damaging

Letters, 30 March

From Nigel Tuersley, Wardour, Wiltshire, UK

Sam Edge's correspondence and Alison Flood's insightful interview with Tali Sharot (2 March, p 40) both focus on habituation to negative signalling. But becoming inured to misleadingly optimistic scenarios can be just as dangerous.

To give just one example, the notion of interstellar travel is chimerical, and discussion about populating distant worlds lends spurious credibility to suggestions for ways of confronting extreme technological and physiological challenges that may never be surmounted. An unintended consequence of this belief is a tendency to consider the only habitable planet to which we currently have access as ultimately expendable – indeed, escape to a planet as-yet untouched by humanity is frequently cited as justification for our current trajectory. ▮

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Sound of silence

A new understanding of hearing could not only fix tinnitus, but reverse some types of deafness too, discovers **Clare Wilson**

WORKING as a DJ in Liverpool, UK, a decade ago, James Rand would often leave work hearing strange sounds that he knew weren't real – a high-pitched whine or a low rumble. These symptoms of tinnitus always disappeared by the time he awoke… until, one day in 2017, they didn't.

A doctor confirmed that the sounds had probably been caused by Rand's exposure to loud music for hours at a time. There were no treatments, bar ways to help him get used to it. "I knew I was never going to hear silence again," he says. "It was incredibly depressing."

Today, though, the prospects for treating tinnitus aren't so bleak. New research has led to neurostimulation devices that reduce the sounds' volume. Moreover, several treatments are in development that could even silence tinnitus completely. "For the first time, we're talking about a possible cure," says Stéphane Maison at Harvard Medical School.

These insights have also shed light on a common cause of hearing loss. In fact, they suggest that some of the same treatments for tinnitus could also restore hearing in people who have become partially deaf with age. "It has completely changed the way we think about hearing loss," says Maison.

Tinnitus is one of the most common long-term medical conditions, affecting up to a quarter of older adults. While the whining and rumbling experienced by Rand are common forms, others may hear whistling, humming, clicking or even musical hallucinations. The sounds can be intrusive and distracting, sometimes leading to depression, anxiety and difficulties sleeping. They can also interfere with hearing. Rand was worried it would affect his job as a music producer, his main career. "I work in music and I'd killed my ears," he says. "I spent a long time being angry at myself."

When someone first seeks help for tinnitus, doctors usually try to rule out potentially treatable causes, such as a build-up of earwax or a reaction to medication. But most people end up being advised to find some way to live with it, using strategies such as talking therapies, hearing aids to stop tinnitus interfering with real sounds, or white noise to mask tinnitus sounds while going to sleep.

Illusory sounds

That is set to change. In the past 15 years, major advances have come from investigating the links between tinnitus and hearing loss. Doctors have long known of the connection between the two conditions. For instance, if people have hearing loss at certain sound frequencies, they often hear a whine at the same pitch. It is even possible to trigger temporary tinnitus by wearing heavy-duty earplugs for several days to mimic hearing loss.

Yet the link between tinnitus and hearing loss is paradoxical: the former is hearing things that aren't there, while the latter is being unable to fully hear. The leading explanation for this link is that the loss of input from the ears causes the brain to compensate by becoming more sensitive – sometimes called the central gain theory. As a result, the brain creates the illusory sounds of tinnitus in a similar way to how someone with an amputated limb may feel phantom sensations from the missing body part.

But there is a problem with this hypothesis. There are some people, like Rand, who have tinnitus but have normal results on hearing tests – up to a quarter of those with the condition, by some estimates.

An explanation for this has come from our growing understanding of how hearing can be damaged. Ordinarily, sound waves pass through the eardrum and reach fluid inside a spiral chamber within the inner ear called the cochlea (see graphic, page 34). Cells with tiny hairs that are buffeted by this fluid turn sound waves into electrical impulses that travel along nerves to the brain. These hair cells gradually die off as we get older, especially the ones that register high-frequency sounds. For a long time, the assumption was that loud noise also damages hearing by killing hair cells. But in 2009, work in mice discovered another culprit.

Sharon Kujawa and Charles Liberman at Harvard Medical School showed that, under moderate noise overexposure, the nerve fibres that carry signals from hair cells to the brain are more vulnerable to noise damage than hair cells are. What's more, the damage doesn't affect all the fibres equally. While they look similar, in reality, there are at least three different types, letting us process sounds at different volumes: quiet, intermediate and loud. The ones that process loud sounds are most susceptible to damage. "This got people's attention," says Liberman.

The findings – which were replicated in a variety of different animals – have several important implications. The first is that, if hearing loss that happens with ageing follows the same pattern, it explains why it is so common for older people to have difficulties understanding speech ›

in noisy surroundings, like in a restaurant. Presumably, in some people, the nerve fibres that respond to quiet sounds are fine, but the nerves that respond to loud sounds have been damaged, says Liberman.

A second implication relates to the cause of tinnitus. People who have the condition but have good hearing, according to the standard hearing test known as an audiogram, have long been a stumbling block for the central gain theory. However, if they had damage solely to their loud nerve fibres, this wouldn't show up as hearing loss in an audiogram, which only measures the quietest sounds that people can hear. This strengthens the case for the central gain theory. "It presented a new way to think about people whose audiograms are normal, but who have tinnitus," says Liberman.

Two years later, Roland Schaette and David McAlpine at University College London showed this could indeed be happening in people, as well as animals. They found that people with tinnitus but normal results in hearing tests had lower activity in the nerves leading from the ear to the brain, compared with those without tinnitus and normal hearing – supporting the idea that the brain is getting less input from the damaged "noisy nerves" and so responds by generating the phantom sounds of tinnitus. The researchers also proposed that the condition of having hearing problems only in noisy environments be called hidden hearing loss, a term that has stuck. These findings have since been confirmed in larger groups of people, including in work by Liberman, Maison and others published in November 2023.

The evidence that noise exposure can affect cochlear nerves to cause hidden hearing loss, even before it kills hair cells, is starting to be taken more seriously, says Liberman. But it is still unknown how common this form of hearing loss is, as it is such a recent discovery.

Rand says that his experience fits the description of hidden hearing loss. Standard tests indicate his hearing is fine, but he has difficulties understanding speech in noisy environments. "My hearing is quite bad if I'm walking with my son with the background sound of cars," he says. "I'm constantly having to stick my ear closer to him."

The crucial 2009 findings in mice have a further implication, and it is one that offers hope about new treatments. The old idea, that the main effect of noise exposure is to kill hair cells, meant that to reverse the damage, new hair cells would have to be created – a formidable challenge. But repairing cochlear nerve fibres may be more achievable. The animal work showed that the initial damage is to the nerves' synapses – the connections they make with the hair cells – progressing along to the first part of the fibre. What remains is a crucial part of the nerve cell called the cell body, along with the second half of the nerve fibre, which continues on to the brain. "The exciting thing is that the cell body and the rest of the fibre can remain alive [after the initial damage] for decades," says Maison.

That is good news because previous work has shown that fibres and synapses can be coaxed to regrow by natural signalling molecules called neurotrophins. In the ear, focus has turned to one called neurotrophin-3, which normally promotes synapse formation in the ear in developing embryos, says Gabriel Corfas at the University of Michigan.

One hurdle is that neurotrophins are

Prevention is better than a cure

Most people are aware that excessive noise exposure can lead to hearing loss and tinnitus (see main story). But it is hard for people to know exactly how loud is too loud, says Will Sedley at Newcastle University, UK.

Damage to the ears can be caused by both short bursts of very loud noise and prolonged exposure to moderately loud noise. Common sources of dangerously loud noise include work environments, such as factories, the military and the music and e-sports industries.

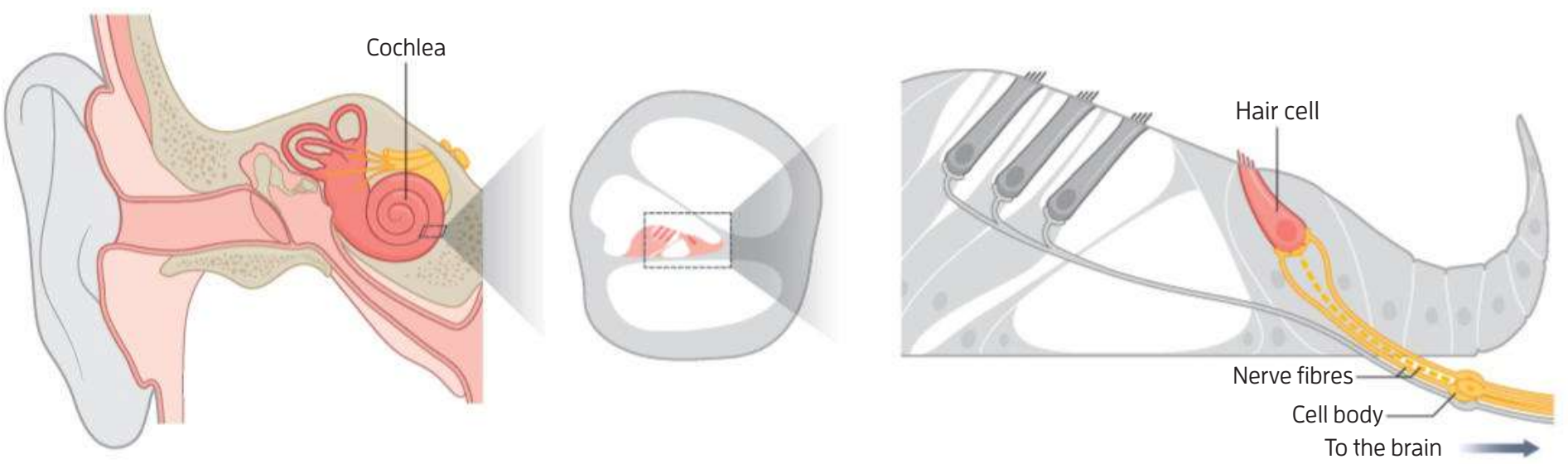
Outside work, we may damage our ears at concerts, in nightclubs or by listening to music via headphones at too loud a setting. "There are very clear noise exposure guidelines. My impression is they are ignored by everybody, whether it's the listener or people who run concerts, clubs and bars," says Sedley.

He recommends that people follow the "60-60" rule when using headphones, which means you should listen at no more than 60 per cent of the maximum volume for no longer than 60 minutes.

"For any venue, if it's uncomfortably loud, wear earplugs," says Sedley. "If you come out with temporary tinnitus, that means you [also] have temporary hearing loss and you've also accrued a little bit of permanent hearing damage."

How we hear

Sound waves enter through the ear canal and reach the spiral-shaped cochlea. Hair cells within the cochlea turn sound into electrical signals, which travel along nerves to the brain. Loud noises can damage these nerves (dotted)



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CHARLIE RAVEN/ALAMY

Loud noise can damage the nerves that send signals from the ears to the brain

large protein molecules, which makes them hard to deliver to the inner ear, but there are possible workarounds. Corfas and his colleagues have used gene therapies to boost levels of neurotrophin-3 in the inner ears of mice, which leads to synapse growth. In one experiment, they were even able to give the animals more synapses than normal, which gave them superior hearing.

Niliksha Gunewardene at the Bionics Institute in Melbourne, Australia, and her colleagues have recently shown that in animals, an injection of neurotrophin-3-loaded nanoparticles into the ear releases the compound for several weeks. Further along is a French firm called Cilcare, which has several drugs in the works that trigger production of multiple neurotrophins. Its lead compound – which Cilcare isn't yet identifying publicly – has already been shown to be safe in people when given orally for a different medical condition. The firm is due to start a trial next year in people with hidden hearing loss, with or without tinnitus.

Strategies such as these, which could potentially reverse both hearing loss and tinnitus, may still be some years away from reaching the clinic. But a different approach, designed to turn down the volume of tinnitus, is already starting to bear fruit. It is based on further insights about exactly how the brain produces these phantom sounds. Work by several groups has shown that this happens primarily within a site at the base of the brain called the cochlear nucleus, where the cochlear nerve fibres enter and make connections with brain cells. According to studies in animals, this is where activity is raised to compensate for the lack of input from the ears. "The circuits become self-stimulating," says Susan Shore at the University of Michigan. "And the rest of the brain thinks there's a sound in the absence of external sound."

Tinnitus hack

Despite its name, the cochlear nucleus also has inputs from other parts of the body, including touch neurons from the face, jaw and neck, which may be to suppress sounds caused by movements of the body, such as chewing. This could explain why many people with tinnitus can change the pitch or loudness of their phantom sounds by moving their jaw or neck, and also why tinnitus occasionally begins after a head injury, says Shore.

Homing in on the site where tinnitus sounds are generated has enabled attempts to hack this process. There are now two companies producing devices aimed at reducing tinnitus symptoms by providing sounds alongside electrical stimulation of touch neurons. The idea is that, over time, this reduces the overactivity of the auditory circuits within the cochlear nucleus.

A firm co-founded by Shore, called Auricle, uses electrodes placed on the jaw or neck to deliver stimulation, followed 5 milliseconds later by pulses of sound at the same frequency as the person's tinnitus. In a trial in 99 people, using this equipment for 30 minutes a day for six weeks reduced the loudness of their tinnitus compared with a control treatment that delivered the sound alone. Auricle is in the early stages of an approval application.

Neuromod Devices, a company based in Dublin, Ireland, has already received approval for a similar device called Lenire, which was launched in Europe in 2019 and in the US last year. Lenire delivers electrical stimulation to the tongue at the same time as the person listens to sounds through headphones. The firm has carried out three trials showing that the severity of people's tinnitus reduced with the treatment, although it didn't compare the stimulation with a placebo version, which would have been a more rigorous test, says Will Sedley at Newcastle University, UK.

It is possible that both strategies – to regrow the damaged parts of cochlear nerves and to turn down activity in the cochlear nucleus via electrical stimulation – could help people with tinnitus, says Sedley. But he warns that there are potential downsides if people pin their hopes on eradicating their symptoms. At the moment, the approach with the most supporting evidence is using talking therapies that help people learn to live with the sounds, he says. "I've heard a number of people talk about declaring war on their tinnitus," he says. "What's really evidence-based and currently available are ways to make peace with it."

That philosophy chimes with Rand's experience. Contrary to his initial fears, his symptoms didn't interfere with his music career and he has now come to terms with his tinnitus. "It doesn't feel that intrusive in the day and I have grown used to it at night," he says.

At work in mixing studios, however, Rand is fastidious about making sure sound levels don't get too high, so as to avoid further hearing damage. And he advises everyone to wear hearing protection at clubs and concerts. "You get one pair of ears, so look after them," he says. "I miss silence and guarantee you would too if you lost it." ▮

Clare Wilson is a health reporter at *New Scientist*

Mind the gap

RYAN WILLS; KLAUS VEDFELT/GETTY IMAGES

We appear to live in a patch of space so vast and empty that it breaks the laws of cosmology. To explain it, we may have to reimagine gravity, says **Miriam Frankel**

EVER feel like you are stuck in a hole? Newsflash: you are. Astronomers call it the "local hole", but that is quite the understatement. It is vast, gigantic, enormously huge – although, in truth, adjectives fail us when it comes to this expanse of nothingness. It is the largest cosmic void we know of, spanning 2 billion light years. Our galaxy happens to be near its centre, but the trouble with this hole isn't that it presents a proximate danger – more that it shouldn't exist at all.

That is, if one of our most firmly held beliefs about the cosmos is true. That assumption, known as the cosmological principle, says that the universe's matter should be evenly distributed on the largest scales. It is the cornerstone on which much of modern cosmology is built. If the void is real, then that stone might be crumbling.

For this reason, few dared to believe the void could be genuine. But evidence has mounted in recent years, and astronomers have moved from doubt to begrudging acceptance. They have also discovered other similarly vast structures. So now the question is being asked with increasing urgency: if we really are living in a void, do we need to drastically modify our models of the cosmos? That might involve rethinking gravity, the nature of dark matter, or both.

The idea that the universe has the same character through and through can be traced back at least as far as Isaac Newton. He argued that the motions of the stars and planets can be explained by a law of universal gravitation that applies in the same way, everywhere. Today, a similar idea applies to the distribution of stuff. The cosmological principle says that the universe should be both isotropic and homogeneous, meaning its larger-scale composition should look the same in every direction, no matter where you observe from.

There is a clear rationale for this. Just after the big bang, matter would have been contained in an exceedingly dense ball, which then ballooned in size during an epoch we call inflation. This very rapid period of expansion would have smoothed out the density of matter, ultimately leading to a universe in which galaxies are evenly distributed.

Today, these ideas are baked into the standard model of cosmology, our supremely successful explanation of how the cosmos grew and took shape. Along with the cosmological principle, the model also includes the assumption that the universe consists mainly of unidentified dark energy and dark matter, the first exerting a force linked to the continued expansion of the cosmos, and the second an unidentified substance that only interacts gravitationally with other matter. Based on this, the model perfectly explains key features of the cosmos, including the amounts of helium and deuterium made in the first few minutes of the universe and the pattern of light left over from the big bang, known as the cosmic microwave background.

But think of the universe as being like crunchy peanut butter rather than the smooth variety. This is because the cosmological principle is statistical in nature, meaning the universe is smooth on average, but clumps and gaps aren't completely forbidden as long as they aren't too numerous. Plus, we would expect gravity to have pulled matter together into large structures, but only up to a point, given the age of the universe. Oddities within this general evenness may crop up, but they should be rare. "You can calculate the probability of these kinds of structures and it may be very low – but it is not zero," says astrophysicist Priyamvada Natarajan at Yale University. The bottom line is that we don't expect to see voids or structures wider than about 1.2 billion light years.

The first hints that our part of the universe was thumbing its nose at this came in 1990, when Thomas Shanks at the University of Durham, UK, and his colleagues looked at a survey of our cosmic locality, made up of optical photographs, and counted the number of galaxies. They found fewer than they expected. In 1997, a team of astronomers counted the galaxies in the same region based on infrared images and found the same.

Maps of nothing

The evidence hardened further in 2013, when three researchers – Ryan Keenan at the Academia Sinica Institute of Astronomy and Astrophysics in Taiwan, Amy Barger at the University of Wisconsin-Madison and Lennox Cowie at the University of Hawaii – looked again using a cutting-edge infrared survey. They found the same low density of galaxies and, crucially, mapped out the structure of the void. "It became very clear that there was a local under-density," says Cowie. The trio found that we live in a 2-billion-light-year-wide expanse of space with a density about 20 per cent lower than average.

This region is now known as either the local hole or the KBC void, following the initials of its discoverers. But there were lingering doubts over whether it was quite as empty as it seemed. After all, there is plenty of stuff out there that doesn't emit visible or infrared light, and so could have been missed.

However, the void has since been mapped using most of the observational tools at our disposal, including in a 2020 study that looked at X-ray emissions and also concluded that the void was less dense than the universe on average. "The observational evidence is strong," says Shanks. "Counting galaxies is a simple, reliable technique."

That leaves cosmologists with quite the headache. What if the universe isn't as isotropic and homogeneous as we have ›

Super-size me!

Astronomers can't stop finding structures that are shockingly big. As early as 1989, a team discovered a "great wall" of galaxies that is at least 500 million light years across. And measuring in at around 1.5 billion light years from end to end is the Sloan Great Wall, a vast line of galaxies packed together in a linear shape that was discovered in 2003. A decade later, astronomers found the biggest example yet: the Hercules-Corona Borealis Great Wall, which is a whopping 10 billion light years in length. Such giants are in conflict with the so-called cosmological principle, which says that structures in the universe shouldn't be bigger than about 1.2 billion light years.

Since then, more cases have cropped up. In 2021, Alexia Lopez at the University of Central Lancashire, UK, reported a huge arc of matter stretching for 3.3 billion light years. And this year she has found that there is a "big ring" 1.2 billion light years across right next door to the arc. According to existing ideas about the makeup of the universe, there should be a low probability of finding any of these structures; to find two so close together is even more unlikely. "We should think about what these structures could be hinting at, not simply dismiss them as statistical anomalies," says Lopez.

It is possible that some of these observations could be mistakes. Commenting on Lopez's findings, astronomer Thomas Shanks at the University of Durham, UK, says the sighting is interesting, but warns that the eye "is very sensitive to picking up shapes like rings".

Assuming they are real, though, these megastructures seem to be in conflict with the standard model of cosmology, which suggests such massive forms shouldn't be possible. If that is the case, maybe our model of the universe needs adapting (see main story).

"IF THE VOID IS AS HUGE AND EMPTY AS IT SEEMS, A CORNERSTONE OF COSMOLOGY MIGHT CRUMBLE"

always assumed it must be? "Finding that it isn't would really push cosmology into changing things," says Cowie.

He doesn't think the existence of the KBC void on its own is enough to force a panic. But there are other worries. In 2019, Alexia Lopez at the University of Central Lancashire, UK, was trying out a new method to analyse images from the Sloan Digital Sky Survey, which is mapping a vast swath of the sky. Her work used the ability of extremely bright objects called quasars to illuminate fainter matter. In a 2021 paper, she revealed she had discovered an arc of galaxies extending for 3.3 billion light years. This is just one of several astoundingly huge formations discovered over the past few years (see "Super-size me!", above).

Oversized voids and structures aren't the only problem facing the standard model of cosmology. There is also the Hubble tension. We know that the universe is expanding at an ever-increasing pace, given by a figure known as the Hubble constant. The trouble is, various measures of this rate of expansion don't agree. When we gauge it at large scales, the number comes out about 10 per cent lower than when we measure it based on nearby galaxies. In other words, our local patch of the universe seems to be expanding faster than the rest. Just last week, new results emerged that may help soothe the tension, but it remains a contested topic among astronomers.

On top of that, there is the issue of "bulk flows", which refers to the way streams of galaxies move. Last year, astronomer Brent Tully at the University of Hawaii and his colleagues observed these flows in the KBC void and found they were four times as fast as the standard model of cosmology predicts. "These measurements couple with the Hubble tension dispute to suggest a real problem with the standard model [of cosmology]," says Tully.

Crisis management

He isn't the only one who feels that way. Indranil Banik, a researcher at the University of St Andrews in the UK, who has studied the KBC void, says the Hubble tension, bulk flow problem and the void are together creating a crisis in cosmology. He says it is "impossible" to fix it while sticking with the standard model – so it is time to look for other solutions.

That solution must realistically involve a mechanism by which structures can form more quickly than we normally expect. There are only really two options for this. Either you propose a tweak to the strength of gravity, or you adjust the properties of dark matter and the way it exerts its gravitational pull.

Banik and his colleagues recently explored the first of these options, tinkering with an old idea called modified Newtonian dynamics (MOND), which posits that gravity is stronger than normal when operating over very large distances. They calculated how MOND would affect our local environment, assuming that we live in a void with 20 per cent less matter than the cosmic average.

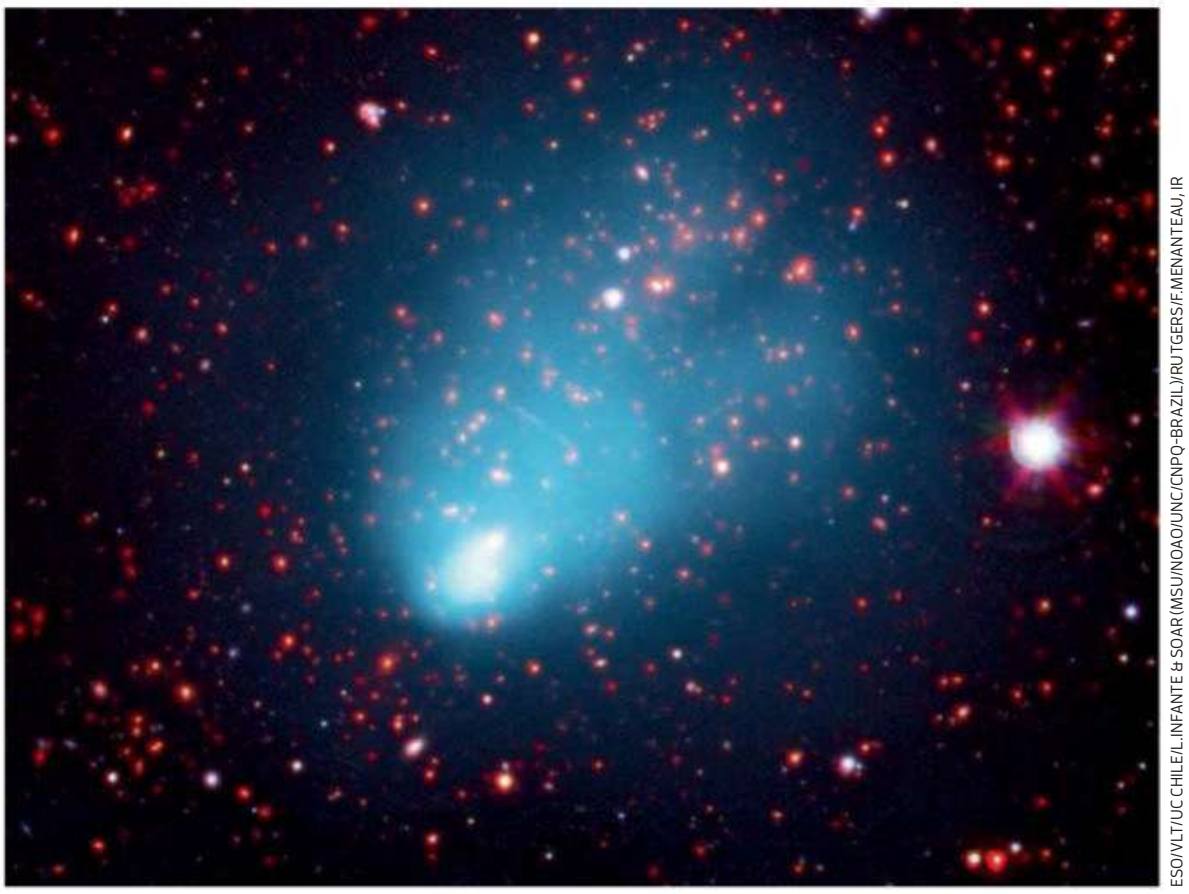
The researchers found that it would naturally result in the local universe expanding faster because matter, including the supernovas and galaxies used to measure the Hubble expansion, would continuously flow out of the region – being gravitationally attracted to the more abundant matter outside the void.

So living in a void would ultimately inflate the local measurement of how fast the cosmos is expanding. The model also matched the latest figures for bulk flows. For Lopez, the results are interesting because they could potentially also explain the behemoth structures she found. "It's good science to follow the data," she says.

Yet MOND is a deeply controversial hypothesis because it does away with dark matter, an idea that is well-supported by observations. Even Banik stresses that he doesn't see his work as the solution to this crisis per se. Rather, he says, it illustrates that some tweak to the standard cosmological model could allow for the faster formation of structures. Banik thinks a less-interventionist version of MOND might do the trick, one where the laws of general relativity are tweaked to make gravity ever-so-slightly stronger on scales above a million light years, but not so much that anything else in the standard model is affected, including dark matter. He points out that the strength of gravity hasn't been tested at those scales yet.

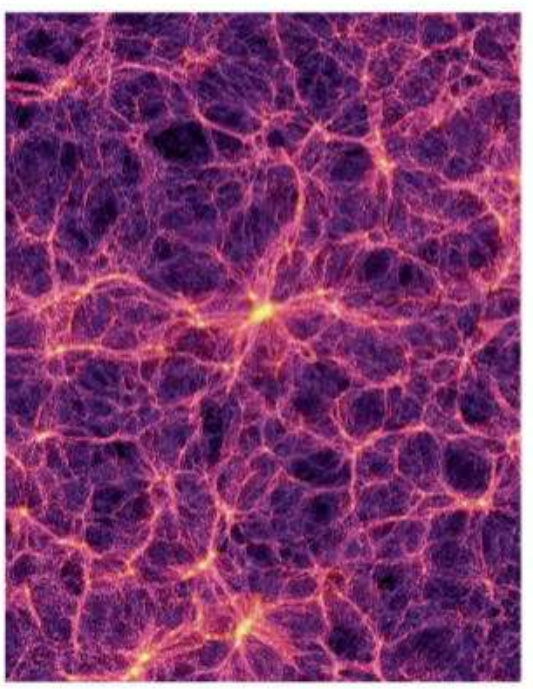
If he is wrong about gravity needing a tweak, then perhaps the void can be explained with an alteration to dark matter. The standard cosmological model assumes that dark matter is "cold", meaning it is slow-moving and barely interacts with normal matter or light except through gravity. The model also suggests that cosmic structures grow hierarchically, with small objects combining to form larger ones. But some cosmologists argue that dark matter may instead be "hot", moving at close to light speed. In such a scenario, dark matter would be made of almost massless particles, such as neutrinos, and structures would form the other way around – starting with giant entities that break apart into smaller objects such as galaxies. This ultimately fits better with the existence of megastructures – and the KBC void – but worse with other observations. Or maybe dark matter interacts with other matter through an unknown fifth force of nature. "You could probably cook up some sort of dark matter interaction either with itself or with baryons [the key components of ordinary matter] that would boost structure formation," says Harry Desmond, a cosmologist at the University of Portsmouth, UK.

There are more outlandish ideas too. One wild option – that nonetheless is allowed in the standard cosmological model – is cosmic strings. These hypothetical strands are thinner than a proton but billions of light years long. Lopez floats the idea that such strings could function as an extra way to gravitationally attract matter. Banik says this is unlikely to be the solution because, even if these strings exist, they would be rare.



ESO/VLT/UC CHILE/L. INFANTE & SOAR/MSU/NOAO/UNC/CNPQ-BRAZIL)/RUTGERS/F.MENANTEAU, IR

The El Gordo galaxy cluster is one extremely large cosmic structure, with the mass of 3 quadrillion suns



VOLKER SPRINGEL/MAX PLANCK INSTITUTE FOR ASTROPHYSICS/SPL

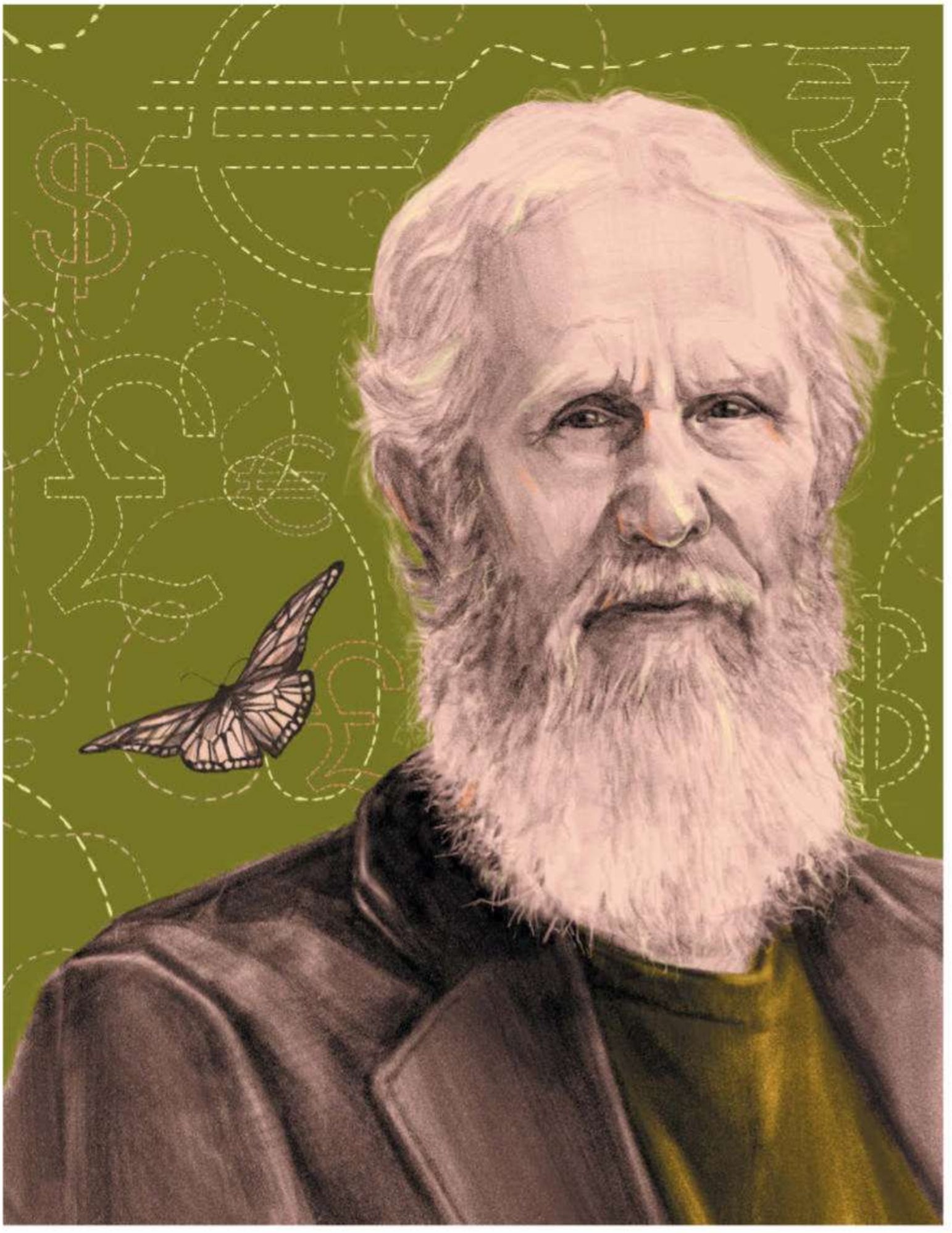
Dark matter is thought to run in filaments across the cosmos

Working out a solution to the void isn't going to be easy, then. Natarajan says our existing cosmological model is "exceedingly difficult to falsify". Even minor adjustments to one aspect may cause unintended problems elsewhere. While changing the nature of dark matter might explain the presence of the void, "I don't know what speeding up structure formation would do to star formation, galaxy formation or black hole formation," she says.

For his part, Shanks wonders if voids might actually be more common than we realise. Most of our data on the structure of the universe is based on bright galaxies – naturally enough, because those are what we can see most easily. Yet it is possible that less-visible matter might cluster very differently, perhaps making large-scale structures or gaping voids more common than we realise. If so, the KBC void would be no outlier.

But assuming our void is as rare as we think – that would be quite something. Over the past century, our interrogation of the universe has taught us the same lesson time and again: we are nothing special. Earth is one of many planets orbiting one of billions of stars in one of billions of galaxies – possibly even existing in one of many universes. The discovery of the KBC void points in the opposite direction; it makes us unusual. If we are living in a hole, maybe that thought is more special than it sounds. ▮

Miriam Frankel is a freelance journalist based in London



ULA ŠVEIKAUSKAITĖ

"The economy is an emergent phenomenon, in which humans are the building blocks"

Traditional economics isn't working, but a radical alternative is now coming of age, as complexity theorist **J. Doyne Farmer** tells Thomas Lewton

IN 2006, economists at the Federal Reserve Bank of New York started to worry about the overheating US housing market. Concerned that the bubble might burst, they used their best model to predict what would happen if house prices dropped by 20 per cent. Not much, was the answer it churned out. Soon after, house prices fell by almost exactly this amount, leading to probably the worst period of global economic decline in a century.

Economics is often lambasted for being a pseudoscience, with dense mathematical formulae that belie its subjectivity and a poor track record of making accurate predictions. J. Doyne Farmer thinks we can do better. In his new book, *Making Sense of Chaos*, he unpicks why standard economic approaches often fail – and presents a radical alternative. Complexity economics, as it is called, treats economies as systems akin to natural ecosystems or Earth's climate. Giant computer simulations based on these ideas offer a better representation of how billions of people interact within the global economy.

Farmer currently holds posts at the University of Oxford and the Santa Fe Institute in New Mexico, but his journey into economics has been unconventional. It began when he dropped out of graduate school, built the world's first wearable computer and used it to beat the casino at roulette. In the 1990s, he set up Prediction Company, where he applied similar principles to the stock market. A pioneer of chaos theory and complex systems, he believes that complexity economics has recently come into its own, making reliable predictions about the world's most intractable economic problems. It is time, he argues, for policy-makers to take note.

Thomas Lewton: Why do we need a more objective economics?

J. Doyne Farmer: One of the problems with mainstream economics now is that, on almost any important issue, there is a diversity of opinions about the right answer. Austerity is a good example. Following the financial crisis of 2008, Wolfgang Schäuble, Germany's finance minister, argued that austerity had to be imposed on the Greeks – that it was the only cure for their failing economy. Others, like Nobel-prizewinning economist Paul Krugman, argued that, no, you had to actually cut them some slack. When economists ›

disagree, they let politicians disagree. In the end, it means that we make our decisions based on gut feelings and beliefs rather than science. I think complexity economics offers the possibility for a more objective economics where the answers aren't begotten by the assumptions.

What are the problematic assumptions that traditional economics makes?

The core idea underlying standard economic theory is that people have utility functions, which score what they like and what they don't like. Often it is simply the fact that households like to consume – the more the better. Or businesses like to make profits – the more the better. These economic "agents" then make decisions that maximise their utility, meaning that they allow them to consume or make as much money as possible. But do we actually have the cognitive power needed to do the calculations that maximise our utility? In the traditional approach to economics, the answer is yes. This idea of *Homo economicus*, whereby people act completely rationally, dominated economics from roughly 1970 until about 2000. Then economists began to realise that *Homo economicus* is a poor model of what people do, at least in most circumstances.

Standard economics also assumes that economic systems, in the long term, settle down and reach equilibrium. For example, an economic market can determine the price for something by balancing supply and demand. But this is only a decent approximation of reality in very simple cases. Economics is a bit stuck now because, on the one hand, it's clear that rationality is not the best model – nor is the idea of equilibrium, in most cases – but on the other hand, if you let go of rationality and equilibrium, the whole mathematical framework that was developed crumbles.

Complexity economics can help us transition to sustainable energy

How does complexity economics differ in its approach?

We treat the economy as a complex system. This specifically means a system where there is emergent behaviour: the system as a whole exhibits properties that are not present in its building blocks themselves. An ant colony is an example of emergence. Each ant is a very simple creature, and yet ant colonies can farm mushrooms, ranch aphids and do all kinds of sophisticated behaviours. The economy is an emergent phenomenon, too, in which humans are the building blocks.

Complexity economics recognises that economies have quite a lot in common with other complex systems, such as ecosystems, biological evolution or even Earth's atmosphere. In complexity economics, we often borrow mathematical tools from other fields to build our models.

In what way is an economy like an ecosystem?

An ecosystem is an interaction of specialist agents: grass is a specialist at extracting energy from the sun and turning it into grass; zebras are specialists at turning grass into zebras; and lions are specialists at turning zebras into lions. Each of those entities strongly depends on the others. If you kill all the lions, that's very bad for the grass, because then the zebras eat all the grass. Similarly, in economies, we are specialised in the jobs we do and the kind of products we make. Predicting the economy is about understanding how all of these specialists interact with each other and what emerges out of the other end.

KRISTOFFER TRIPPLAAR/ALAMY

BJORN WYLEZICH/ALAMY

Practically, though, what do complexity economics models look like?

First of all, good models have what I call verisimilitude: they should follow the same basic principles that the real world follows. The models are agent-based and we try to understand how the agents actually make their decisions. You don't need to know everything about psychology, but it's nice to know as much as possible about how real people make economic decisions.

For example, you might simulate a market containing agents that buy and sell. They might make their decisions based on simple rules like "buy undervalued assets" or "look around at your neighbours to see what they're doing, and copy them if they're doing better than you", or they might use trial and error. Then you can put these rules into a computer and simulate what happens over time. The agents input information and make decisions, their decisions change the economy, then the agents input new information. And you just keep going around and around that loop, letting the simulation evolve with time to see what it does.

VLADIMIR RYS PHOTOGRAPHY/GETTY IMAGES

Standard economics failed to predict the financial crash of 2008 (left and far left)

"Economies have a lot in common with ecosystems or even Earth's atmosphere"

The ideas behind complexity economics have been around since the 1960s. What is driving the current advances in this field?

There are several factors. The most important one is computing power. Computers are now a billion times more powerful than in the 1960s. We also understand a lot more about how people behave and how they make their decisions. And we have vastly more data – which is partly a consequence of increased computer power.

In the past, our agent-based models were typically qualitative. Most of them would simulate an economy in a hypothetical world that had some realistic properties. Now, we're beginning to make models where we can make sharp quantitative predictions. For instance, we can say, for a specific economy, that next quarter's GDP will be a specific number. That's important because it means you can measure how well the model is performing and keep adjusting it to try to make it perform better. This makes the models more powerful. It allows us to keep score of how well we are doing and to go head-to-head with mainstream models.

How does the predictive power of complexity economics compare with that of standard economics?

Even though complexity economics is relatively new and has consumed relatively little human capital so far, there are already examples where it is doing very well. I begin my book with the story of how, shortly after covid-19 struck, I assembled a research team to predict what the economic consequences of the pandemic would be for the UK. Using an agent-based model, we predicted that in the second quarter of 2020, the UK would take a GDP hit of 21.5 per cent. We made predictions before the answer was known. When the dust settled, the answer was 22.1 per cent. For comparison, the Bank of England's estimate was 30 per cent. We also calculated levels of unemployment and several other economic indicators pretty accurately – including what would happen to 52 different industry sectors. This provides a proof of principle that this can really work.

Is complexity economics already being used in the real world?

Some central banks have research teams that are beginning to develop agent-based models for the economy. Those include the Bank of England, the Bank of Canada, the Hungarian National Bank, the Bank of Spain and the Bank of Italy. These are smaller efforts within the larger research teams of those central banks, but it is something that's becoming established now.

What possible applications for complexity economics are you most excited about?

Climate change is a problem where complexity economics can have a big influence. We're going through transitions in our energy systems and food systems that are going to happen very quickly and are going to profoundly change the way we do things. While these are happening, we will be far from equilibrium, and standard economic approaches will be of limited value.

My colleagues and I are designing something called the Climate Policy Laboratory to try to model the different relevant parts of the economy. The model comprises modules that describe energy, agriculture, innovation, finance, production and labour. These can be used separately or together to see how changes in one affect the others. In this way, we will be able to test different policies and see how the transition would play out – for example, how workers will transition to different occupations, or what happens when, say, BP decides to divest from oil and invest in solar farms. The answers are not obvious because of all the indirect network effects. The goal is to make a more just transition as rapidly as possible.

Some economists see economic growth as part of the problem when it comes to climate change. What's your view?

I'm not a fan of no-growth economics. We are going to need a lot of resources to make the transition quickly. We have the technologies, and if we wanted to go on a wartime footing and were willing to make some sacrifices, we could do it all in three years. But people don't seem willing to do that. Pushing the no-growth agenda too hard could alienate people from wanting to take action about climate change and create even more problems.

I think there's a new narrative that's more productive, which is that climate change is a great business opportunity rather than a hot potato to be passed around at COP meetings. People are beginning to realise that whoever makes this happen will get rich. If we can harness this profit motive and guide it and constrain it, we can create a much more sustainable economy in a world that works for everyone. ▮

Thomas Lewton is a features editor at *New Scientist*

The back pages

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Stargazing at home

Looking for the Lyrids

Here's how to spot the Lyrid meteor shower, caused by debris from a comet thought to originate in the Oort Cloud, says **Abigail Beall**

Abigail Beall is a features editor at *New Scientist* and author of *The Art of Urban Astronomy*. Follow her @abbybeall

ONE of the meteor showers I look forward to every year is the Lyrids, which peaks this year on 22 April. Its display will be dampened this time round by the bright light of the waxing moon, but it is still worth finding a clear night to spot its shooting stars.

The best time to watch the Lyrids – or any meteor shower – is after midnight local time. The shower is expected to be active from 15 to 29 April, peaking between the evening of the 21st and the morning of the 22nd. So, look at the weather forecast around the peak and pick a time when it is likely to be clear, as this will have the biggest impact on whether or not you see any meteors.

On a moon-free night, you can expect 10 to 15 meteors to be visible every hour during the Lyrids, but since the full moon is on the evening of 23 April this year, the fainter meteors will be obscured by its light. Try to avoid other sources of light pollution, too, like bright streetlamps.

The Lyrid meteor shower, pictured, is best viewed from the northern hemisphere because the point from which its meteors appear to come, known as the radiant, is only visible from there. But southern hemisphere stargazers might get lucky too, as meteors can streak across the sky in any direction.

To spot the radiant in the northern hemisphere, you need to start by tracking down the small constellation Lyra, which is named for Orpheus's lyre in Greek mythology.

SHUTTERSTOCK/INGO BARTUSSEK

This is easy: first, find the pattern of stars known as the Summer Triangle, so named because it is made up of three bright stars in a triangle shape and, in summer in the northern hemisphere, around midnight, it appears directly overhead. In late April, at midnight, the three bright stars will appear near the eastern horizon. The highest of these is Vega, and this is in Lyra.

In the southern hemisphere, look towards the north for a chance of spotting some Lyrid meteors. But watch any direction of the sky long enough and you will probably see some.

On any given night stargazing, you can expect to see a meteor or two every hour. These flashes of light streaking across the sky are created by dust and debris hurtling into Earth's atmosphere from space. The detritus is slowed down by molecules in the atmosphere, releasing energy that is given off as light.

When Earth's motion around the sun takes it into a patch of debris left behind by a comet or asteroid, we get meteor showers. The Lyrids are caused by the aftermath of a comet called C/1861 G1, or Thatcher, discovered in 1861. Thatcher takes 415 years to orbit the sun, and is thought to originate from an outer part of the solar system called the Oort Cloud. It will be visible again around 2283. ▮

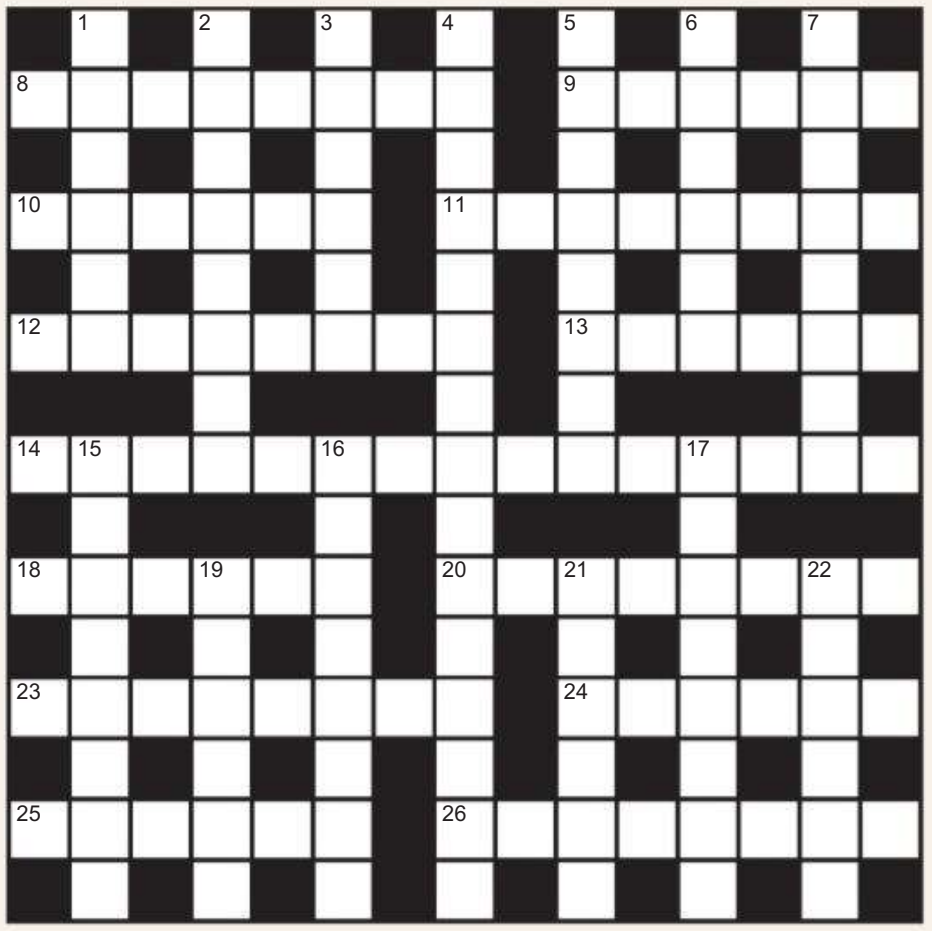
Stargazing at home appears every four weeks. Share your stargazing successes with us on X and Instagram @newscientist, using the hashtag #NewScientistStargazing

These articles are posted each week at newscientist.com/maker

Next week

Mathematics of life

Quick crossword #156 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

8 Bacterial skin infection (8)
9 Queasiness (6)
10 Metal beam (6)
11 Sleeplessness (8)
12 Sb (8)
13 Turn around (6)
14 Concerning the heart and lungs (15)
18 Fit; assault (6)
20 Areas of thick skin around hairs and fingernails (8)
23 Cone-like plant structures (8)
24 Songbird in the tyrant flycatcher family (6)
25 Disconnect (6)
26 Marine mollusc (8)

DOWN

1 Embryo membrane (6)
2 Oncoming breeze (8)
3 Bacteria genus that may cause food-borne infection (6)
4 Urination and defecation, for example (6,9)
5 0.1 nanometre (8)
6 Peak (6)
7 Passive electrical component (8)
15 At (8)
16 Federal research laboratory in Tennessee (3,5)
17 Premature cell death (8)
19 US crewed space-flight programme (6)
21 Infectious disease (6)
22 Er (6)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #248
set by Bethan Ackerley

1 Who is credited with first proposing nuclear pulse propulsion, a hypothetical method of propelling spacecraft via nuclear explosions?

2 What was the first plant to have its whole genome sequenced?

3 In mathematics, the principle that a point within certain types of moving system will eventually visit all parts of the space that the system moves in is known as what?

4 The tiny mites of the *Sarcoptes* genus cause which condition?

5 In which organ would you find Koch's triangle?

Answers on page 47

BrainTwister
set by Katie Steckles
#16 Order, order!

Arrange the digits 1-9 in a line so that each pair of adjacent digits differs by either 2 or 3.

Arrange the digits 1-9 in a line so that each pair of adjacent digits sums to a prime number.

Now arrange the digits 1-9 in a line so that each pair of adjacent digits (when read as a two-digit number) appears in the times tables from 1 × 1 up to 9 × 9.

Solution next week

Buzzing off

How come, when the front door of my house is open, a fly can enter my home easily, but not escape as easily out of the same door?

Lucy Singh
Wantage, Oxfordshire, UK
My experience is that blue and green bottle flies are perfectly able to escape out of the door when they want to. I suspect they mostly just don't fancy it – possibly because they like the still air indoors. I find that when they feel threatened, they can zoom straight through two doorways to get to the outside, even if they have spent some time bumbling against the window beforehand.

To make a fly feel threatened, you can wave a cushion at it as though you are trying to swat it in mid-air. If you manage to make contact with it, you are unlikely to harm it (which is important to me), but you will find that it then flies directly out of the house.

If it dodges the cushion, you will have to flap at it a few times so that it can't settle anywhere. It won't enjoy this and will eventually decide it has had enough, then zoom straight out of the door.

"In the absence of a sentient being controlling door access, flies in your home are a statistical inevitability"

No flies were harmed in these experiments, but I am sure they got rather annoyed.

Eric Kvaalen
Les Essarts-le-Roi, France
I would say it is an entropy effect. It is like a situation where you have air outside a room and a vacuum inside. When you open the door, the air comes in and doesn't immediately go back out. The air molecules are like the flies: there are lots of them outside and when you open the door, one or more happen to come in. They may eventually go back out, just as any air molecule may, but it will take a while before that happens. In the end, you will have the same concentration of flies indoors as outdoors, on average. Unless there is something about your house that they like!

Ron Dippold
San Diego, California, US
I think it is mostly a matter of odds. Imagine a 2D architectural diagram of a house's ground floor seen from above with an outside door open. There are hundreds of flies (dots) randomly buzzing around outside. Your door is relatively tiny, but eventually one of them will wander through – let's call him Liam.

Liam doesn't really grasp the concept of "inside" versus "outside" your house and is just semi-randomly flying around smelling for nasty stuff to eat. Now imagine the dot that is Liam buzzing around your house – most buzzes don't end up with him going out of your open door before the outside dots that are Noel and Tony also randomly end up inside.

So it is just a consequence of the fact that there are orders of magnitude more flies outside your house who might randomly get in. If you had thousands of flies inside your house (nooooo), some would randomly find their way out of your door as well.

Of course, there are some flies that do eventually try to go somewhere else because there isn't enough food inside, but they have no idea where the door is and just go for the nearest sky – which is your closed window. So an even worse choice than a random one.

Alan Cooper
Glasgow, UK
Maybe the fly could, but it chooses not to. Perhaps your home is warmer, brighter, smellier or otherwise more attractive than the outside world.

But, even if not, this is simply a manifestation of statistical mechanics, entropy and the second law of thermodynamics at the macroscopic level. Once the front door of your home is open, the population density of randomly flying objects (flies) inside and out will equalise to a thermodynamic equilibrium.

In the absence of a Maxwell's demon or other sentient being such as yourself controlling door access, flies in your home are a statistical inevitability.

Jeff Stanton
Sydney, Australia
During tests in an office where the front door was often left open, it was found that turning off the fluorescent lights encouraged annoying blow flies to find their way out the door. They flew back and forth, eventually finding the door and going away. This led to a hypothesis that they are attracted to UV light, which is supported by the dead flies often found on window sills. It seems that flies can't tell the difference between a door and a window.

Sadly, there are no records, as the original hypothesis arose from observation during a morning tea break. Subsequent observations showed that turning off the lights did encourage the flies to go outside. An unfortunate side effect was a decline in office productivity during the lights-off periods.

Spencer Weart
Hastings-on-Hudson, New York, US
Point one concerns statistical

SHUTTERSTOCK/FOTOHELIN

Is this child old and wise enough to make it alone in a wilderness?

This week's new questions

Child's play **At what age would a human child be capable of surviving in the wild?** ***Derek Johnson****, Moreton-in-Marsh, Gloucestershire, UK*

Height of change **As average sea levels rise, will contour lines and spot heights on maps need to be recalculated? If so, when?** ***Mark Bean****, Southampton, UK*

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Tom Gauld
for New Scientist

ALAN KEEPS A SECRET STASH OF BISCUITS IN THE FARADAY CAGE, DANIELA TAKES AFTERNOON NAPS IN THE CYCLOTRON AND SANJAY USES THE SUPERCOMPUTER TO RUN HIS FANTASY FOOTBALL TEAM.
I REALLY MEANT "HAVE YOU MADE ANY INTERESTING SCIENTIFIC DISCOVERIES IN THE LAB?"

mechanics. There are many more flies outside than inside, so if they all move randomly, it is more likely for one of them to come in than for the single one inside to go out (think of your house as a container with low fly pressure).

Point two concerns perception psychology. You are very aware of that buzzing nuisance inside, but you don't perceive flies outside that may be trying to get in.

And point three concerns biology. Your house smells like food. Why would the fly want to leave?

Gillian Peall
Macclesfield, Cheshire, UK
How do you know it is the same fly?

All that glitters

Why do humans like sparkly things?

Timothy Bessonette
Wesson, Mississippi, US
For thousands of generations, humans have walked this Earth, adapting to every environment.

One common thread among all prehistoric humans was the dependency they developed on lithic materials – ones made from rocks or minerals. Much of their lives would have revolved around searching for and utilising these materials.

"Many of the stones needed to make tools would have glistened. The ability to identify them would have been vital to survival"

Many of the stones (quartz, obsidian and lots of other microcrystallines) ideal for turning into tools would have glistened. The ability to identify these materials would have been paramount to the survival of our species.

The use of these stone tools helped early humans achieve a surplus in their day-to-day lives, one that afforded the development of culture and artistic expression.

From there, it is easy to imagine that some of these materials being utilised for tools would transcend the need for survival and become objects of artistic expression. Perhaps our attraction to shiny objects was cultivated over thousands of generations, because our survival depended on it.

Mark Thompson
Tewkesbury, Gloucestershire, UK
Humans really like shiny things. One hypothesis involves going back to the cradle of civilisation in Africa where our ancestors were walking over the endless savannah, before spotting that life-saving shimmer of water.

For all our years on this planet, we could never live far from that shine.

Laura Schueler
Franklin, Kentucky, US
I believe it goes back to our early days when food and water required more effort to obtain. Water is especially crucial, so humans would look for it using sparkly reflections from sunlight or moonlight. Water equals life, so sparkly things bring us life! ▮

Answers

Quick quiz #248 *Answers*

1 Stanisław Ulam
2 *Arabidopsis thaliana*
3 Ergodicity
4 Scabies
5 The heart

Cryptic crossword #133 *Answers*

ACROSS 7 *I Robot*, **8** Inhere, **9** Flux, **10** Lovelock, **11** Exhibit, **13** First, **15** Valve, **17** Plumbum, **20** Thank you, **21** Muck, **22** Anyone, **23** Catkin

DOWN 1 Prolix, **2** Ibex, **3** Otalgia, **4** Sieve, **5** Thallium, **6** Wrecks, **12** Inventor, **14** Flounce, **16** Athens, **18** Urchin, **19** Pyrex, **21** Mite

#15 Domino strips *Solution*

There are five ways to cover a 4 × 2 rectangle and 13 ways to cover a 6 × 2 rectangle.

Any n × 2 rectangle can be covered using all the same ways you found to cover an (n – 1) × 2 rectangle, you simply add a vertical domino to cover the additional 1 × 2 column. It can also be covered using all the same ways you found to cover an (n – 2) × 2 rectangle, just with a pair of horizontal dominoes to cover the two new 1 × 2 columns. So, the number of ways to cover any n × 2 rectangle is the sum of the ways to cover an (n – 1) × 2 rectangle and an (n – 2) × 2 rectangle.

Because there is one way to cover a 1 × 2 rectangle and two ways to cover a 2 × 2 rectangle, this makes Fibonacci numbers: 1, 2, 3, 5, 8, 13 and so on.

Boxing: thinking outside

From time to time, the sport of boxing changes its rules. But for the most part, it still requires that each participant in a match be both human and alive. (Exceptions do occasionally pop up – kangaroos are the heavyweight exemplars.)

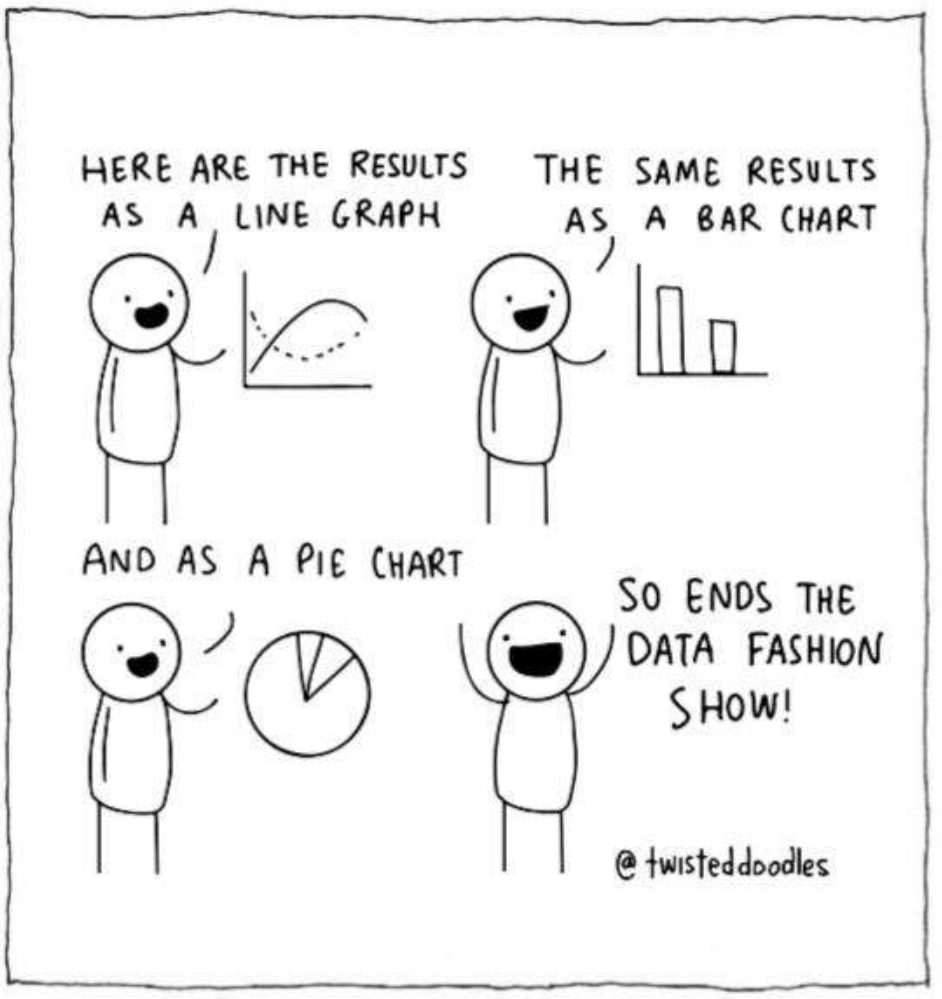
Joseph Lee at Flinders University in Australia has explored a way to expand boxing's rigid traditions. He outlines his thinking in a study in the journal *Ethics and Philosophy* called "Thinking outside the ring of concussive punches: Reimagining boxing".

Lee performs a thought experiment. He "imagines a fight between a human and a robot". This imagining produces, he writes, a realisation.

"A demand for robot-human boxing may occur or not. Certainly, the supply of robot boxing opponents is theoretically achievable," he writes. "With the right programming, a contest against a future machine can be as daring as [a matador] facing up against a bull."

The main benefit, he says, is obvious: "The essential elements of boxing would be retained for humans, accompanied by an overall decrease in boxing-related brain injuries when the number of live opponents is reduced."

Twisteddoodles *for New Scientist*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Classified walls

Taxonomists work to classify things, to build conceptual walls that separate each variety of something from all the other varieties of that thing. There exists a taxonomy of snakes, of melons, of viruses, of distortion-oriented presentation techniques – of almost any variegated kind of object or concept. There is even a taxonomy of taxonomists.

Feedback learns, thanks to reader Dave Brooks, that there is a taxonomy of stone walls, outlined in "Taxonomy and nomenclature for the stone domain in New England".

Are there good taxonomies of stone walls in other places? Feedback would enjoy knowing.

Economics of surfing

What is the value of surfing, if you express it as money?

Surfing is a "more frequent and intense activity" than merely visiting a national park and therefore is "likely to have greater effects on per capita mental health gains and economic value", say Ralf Buckley at Griffith University in Australia and Mary-Ann Cooper at Andrés Bello University in Chile.

They try to calculate that economic value in a study published in the journal *npj Ocean Sustainability*.

The pair reckon that the value of stress reduction via surfing is "estimated at ~$5000 [US] per person per year". They further reckon that for the nation of Australia, this amounts to about $1 billion to $3.3 billion per year.

Of their endeavour, Buckley and Cooper say: "This appears to be a novel approach, distinct from previous research." No one, so far, has risen to contradict that.

Car jeers and cheers

Some researchers are strongly anti-car. Others, perhaps fewer in number, are anti-anti-car.

The thrilling horror sometimes caused by cars – billions of people careening towards possible injury and even death – drove Patrick Miner at the University of Edinburgh, UK, and his colleagues. Drove them, that is, to amass a report in the *Journal of Transport Geography* called "Car harm: A global review of automobility's harm to people and the environment".

How many billions of people are affected? Since the year 2000, they say, "an estimated 2 billion people have been injured in motor vehicle crashes – up to 1 in 4 people alive today – not accounting for repeat injuries or population change". And that's not to mention the other kinds of problems they list, such as social inequities and damaged ecosystems.

Meanwhile – well, not exactly meanwhile, but rather 17 years ago – Roger Roots, a graduate of the University of Nevada, Las Vegas, tried to apply the brakes to that truckload/lorryload of worries.

In his perhaps pre-emptive report called "The dangers of automobile travel: A reconsideration", published in *The American Journal of Economics and Sociology*, Roots rode roughshod over the purported problems. The dangers of automobile use "are substantially lower than the dangers posed by early horse-driven and steam-driven transportation methods, especially in terms of fatalities per mile", he wrote.

Roots went on to found Lysander Spooner University in Montana, an institution that, though little known (it is unclear whether the university has any students), modestly boasts that it is "dedicated to truth and free inquiry, and to educating the politically and socially estranged. We are low cost and high quality. The world's first truly antigovernment university." Of all the world's universities, it may be the most fervently driven to theory.

Dead ant repellant

Visits to a cemetery may occasion a lively conversation for entomologists and exterminators who read a recent study by Thomas Wagner and Tomer Czaczkes at the University of Regensburg, Germany. The study in question is called "Corpse-associated odours elicit avoidance in invasive ants". ▮
Marc Abrahams

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